K. Krishna Murty

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Yellapragada Subba Rao (Auromycin and Hetrazan)










50 Timeless Scientists

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PREFACE

Man's ability to think is the motive power behind all human progress. The desire to discover, ability to create, dissatisfaction at the present and the persistence despite failures are the wheels of development. Chance, serendipity, accident, inspiration or emotional experiences all are Nature's ways but for sure it favors a prepared mind! We now enjoy those fruits from the gardens of Arya Bhatta to Amar Bose, from Charles Goodyear to Charles Townes and from Susruta to Subba Rao.

The story of science is an exciting drama unfolding comedy and tragedy, success and failure. When the tireless inventive geniuses worked dangerously into the frontiers of unknown knowledge, nature cracked its codes in mysterious ways and the laboratories have crackled some time in wonder, some time in humor and some time in mysticism. Science is habitually associated with cloistered laboratories, with cobwebs and cluttered instruments and scientists with disheveled hair, shabby dress, and papers floating around with esoteric ideas and complicated formulas. Hope was in their dreams with courage making them a pristine reality. "It is courage based on confidence, and it is confidence based on experience." After months of perspiration, technical challenges and personal frustration, when the ideas were perfected into practical shapes, all they received was outrageous ridicule. But can we now survive if any one of those marvels were to be removed from our lives?

Nature is an exciting arena and "the great ocean of truth lay all undiscovered before us." In spite of all the scientific breakthroughs and technological marvels, we continue to be small pebbles on the shores of the vast ocean of knowledge.

Haldane's "own suspicion is that the universe is not only queerer than we suppose, but queerer than we *can* suppose!"

Now we have the stories of over fifty great men who dived deep into those queer depths.

Our scientist sages saw the heavens with their naked eyes centuries before it was magnified for the western world. Is there a limit to Chandrasekhar? Our own Benjamin Peary Paul's love for roses raised the curtain for Green Revolution. A British scientist bequeathed his body to an Indian medical college.

Here we have scientists who missed Nobel Prize and those whom Nobel missed. A Nobel Prize awarded to Pauling was branded as an insult! But he is the only one to receive two unshared Nobels. Bardeen promised Swedish king that he would return and he did for another Nobel. An agricultural Scientist received a Peace Nobel Prize. Yes! What is peace without food? Barbara Mcclintock refused to publish her papers anguished at the hostile scientific community, but Nobel committee discovered her in 1983.

Then we have scientists who received awards in prison cells, scientists who made discoveries in the prison cells. Tesla was thrown out of his own labs, cheated by another great man but his alternating current runs our homes now. Carlson went from pillar to post with his photocopy machine and sooner or later we may have a Xerox of human being. Townes received the revelation for LASER on a park bench. When Maiman made the practical Laser, a Hollywood actress wondered if it is a death Ray.

Medicines from Jenner, Pasteur and the like consigned some diseases to history. If only Subba Rao lived a few years more, he would have killed some more diseases. A trio of scientists transformed the twentieth century by inventing the transistor. To top it all, a scientist who was not allowed to go on a holiday invented the microchip.

A school teacher testified in the court to save his old student, Fansworth from greedy corporations for his rightful invention, the television. Davy openly accepted his student as his greatest discovery, Michael Faraday indeed!

New York Times reversed its ridicule ladled out on a rocket scientist after 40 years only after man landed on the moon. Pauli discovered Neutrinos but could not believe their existence. When proved, he kept his promise of champagne casket.

You have them all! It is not a weary chronology of oft repeated Einstein or Newton but a delightful journey into the biographies some of the unsung heroes through their trials and tribulations, eurekas and euphorias, their pleasures and pains, and their dreams and delusions.

They educate and entertain you and you are enticed.

Come in please! Entry not restricted!

Contents

AMAR BOSE

(1929 A.D...)

BOSE SYSTEMS

"I studied violin from age 7 to 14. I loved music, and in my ninth year at MIT, I decided to buy a hi-fi set. I figured that all I needed to do was look at the specifications. So I bought what looked like the best one, turned it on, and turned it off in five minutes, the sound was so poor."

These were Bose's own words. The quest had begun. Those high-ended and high quality stereo systems failed to reproduce the realism of live performance. His research and innovations in the speaker technology and acoustics led him to the present pinnacle where his products can be found in Olympics stadiums, Broadway theatres, the Sistine Chapel, and the Space Shuttle.

That was Amar Gopal Bose, the founder and Chairman of Bose Corporation. With a net worth of $1.8 billion, he was listed on the 2007 Forbes 400.

Bose was born on 2nd November, 1929 in Philadelphia. His father, Noni Gopal Bose, was a freedom fighter who fled India in the 1920s to save himself from British prosecution. Amar Bose studied at Abington Senior High School and later obtained a Ph.D from the Massachusetts Institute of Technology (MIT).

Though he was born and brought up in America, he was an Indian at heart. He recalls:

"The food we ate was Indian, and both my mother and father were very deep into the ancient philosophy of India, so it could well have been an Indian household."

He started supplementing his home income even at an early age by repairing radios, model trains, etc. He recalled later:

"At 13, I realised that I could fix anything electronic. It was amazing, I could just do it. I started a business of repairing radios. It grew to be one of the largest in Philadelphia."

Then Bose spent a year in the research labs at NV Philips Electronics. Netherlands. In the spring of 1956, he came to India to teach on a Fulbright scholarship and he used to read about acoustics at night. He met his future wife Prema, there itself.

He returned to MIT as an Assistant Professor of Electrical Engineering. He survived a kind of apartheid:

"The prejudice was so bad in the United States at that time that a dark person with a white person would not be served in a restaurant. My father, mother, and I would try it occasionally. We would sit there, and the food would never come."

He was disenchanted with the poor quality of even the so-called high-ended systems and started making researches into acoustics, psycho acoustics and spatial acoustics. Reflecting his extensive studies in the concert halls, he said:

"We did experiments with the Boston Symphony for many years where we measured the angles of incidence of sound arriving at the ears of the audience, then took the measurements back to MIT and analysed them."

He went ahead and started designing systems that could reproduce and emulate the concert hall experience in a domestic setting.

He got patents but needed money. MIT professor Y. W. Lee poured all his lifetime earnings and in 1964, Amar founded Bose

Corporation. When his 901® Direct/Reflecting® speaker system was released in 1968, the response was unprecedented and they stood high and mighty for 25 years. His researches into Spatial Acoustics and the human perception of sound resulted in full, rich sound with all the ambience of concert music.

"I really wanted to do research. That has never changed." He often said. With that spirit, his improvements continued to grow unabated. With his acoustic waveguide speaker technology, he developed award-winning Wave® radio, Wave® music system and Acoustic Wave® music systems. Acoustimass® speaker technology brought high quality sound to palm-sized speakers.

However the industry was no bed of roses and he conceded:

"There were a couple of times when we were within two weeks of being non-existent. We passed narrowly over the fire."

Because there was no dearth of ideas and innovation loomed large! He developed audio-demonstrator technology called Auditioner® with which designers and builders can actually feel the sound from Bose systems in their building even while the building is still in a blueprint.

In 1972, he was elected Fellow of IEEE, probably the first person of Indian origin in electronics for his contributions to loudspeaker design, two-state amplifier-modulators, and nonlinear systems.

Dr. Bose and Dr. William Short received 'Inventor of the Year' honour for their Acoustic waveguide speaker technology in 1987.

He continued his love for the research. Home entertainment and automotive audio systems that he developed were simply superb and the experience was heavenly. With the philosophy of research where one hundred percent of their earnings were reinvested in the company, and a great deal of that went into research, his systems conquered international acclaim and demand. His Acoustic Noise Cancelling® headsets are used in the space shuttle. All military and most commercial aircrafts

use the designs that process power from jet engines with Bose suspension system, ElectroForce® linear motion system along with his proprietary software and hardware.

Bose retired from MIT in 2000. He married Ursula Boltzhauser, a senior manager at Bose Corporation, after divorcing his first wife. He received 2007 Distinguished Service Citation awarded to those individuals who have significantly improved the industry or their respective organisations.

Quotes by Bose:

"The excitement level for me working on projects is really not a bit different now from when I was 26."

"No one ever won a chess game by betting on each move. Sometimes you have to move backward to get a step forward."

□□

ARYABHATTA

(476 - 550 A.D.)

MATHEMATICIAN AND ASTRONOMER

If only we lived in the later part of the 5th century A.D., we could have had a glimpse of a brilliant young boy with a halo of genius around him walking from a remote village, Muziris in the deep South India to up north at Kusumapura. Yes, walk it was, the best available transport, next to bullock carts or horses, in those days. That village is the present-day Kodungallour near Thrissur, in Kerala and Kusumapura later came to be known as Pataliputra and now it is called Patna. The western world was still in deep slumber. That boy had a penchant for study at the international residential Nalanda University. That walk marked the first steps towards a Magnum Opus.

On 21st March, 499 A.D., at Khagola, the famous astronomical observatory of the University of Nalanda, the university bells were ringing and the Vedic chants rending the skies and beyond. Seating on a high podium, that boy, now 23-year-old, picked up a pen and started writing on the palm leaf parchment right on dot at the auspicious moment.

Thus started a treatise, which came to be the greatest mathematical manual of all times - 'Aryabhatiya'. It dealt with many aspects of mathematics, like geometry, mensuration,

square root, cube root, progression, the areas of triangles, volumes of spheres and astronomical calculations.

That boy was Aryabhatta, born in the year 476 A.D., destined to be a great mathematician-astronomer. He was soon appointed as the head of Nalanda University by the then Gupta ruler Buddhagupta. Later when his book 'Aryabhatiya' was translated into Latin in the 13th century, floodgates were opened to the European mathematicians towards many unknown mathematical formulae.

The number system we use today, known as the Hindu-Arabic number system, was developed by Indian mathematicians and spread around the world by Arabs. Aryabhatta states that system as 'Stanam Stanam Dasa Gunam' which in English means 'Place to Place Ten Times in Value'. He devised a unique method to represent large unwieldy numbers such as billions in simple words of poetry.

Aryabhatta calculated the value of Pi, as 3.1416, correct to five digits. Aryabhatta gave the area of triangle and was the first mathematician to give what later came to be called the table of Sines. His method to find a solution to indeterminate equations such as 'ax – by = c' is also recognised the world over.

Aryabhatta propounded the theory that the Earth is round and that it rotates on its own axis, creating day and night. He confirmed that the moon shines because of sunlight. He recognised that solar and lunar eclipses occurred because of the shadows cast by the Earth and the moon and not because Rahu and Ketu gobbled the sun and the moon, as some people believe even now. He calculated the time for the rotation of the Earth with reference to fixed stars, (side real rotation) as 23 hours 56 minutes and 4.1 seconds (the modern value is 23:56:4.091), and the length of the side real year as 365 days 6 hours 12 minutes 30 seconds (an error of 3 minutes 20 seconds). Aryabhatta's computation of the Earth's circumference was 24,835 miles. Actual figure is 24,902 miles and his error was merely 0.2%.

Is it not astonishing that Aryabhatta as well as other Indian astronomers made near-perfect predictions and calculations without the aid of the telescope and watching the night sky with naked eye?

He also propounded the Heliocentric theory of gravitation, much before Copernicus, by almost one thousand years before Copernicus gave his theory. Many ancient Indian astronomers had also referred to the concept of Heliocentrism. Aryabhatta had suggested it in his treatise 'Aryabhatiya'.

Aryabhatta hints at the relativity of motion in a passage in his book,

"Just as a man in a boat sees the trees on the bank move in the opposite direction, so an observer on the equator sees the stationary stars as moving precisely toward the west."

His other treatise, 'Aryabhatta Siddhanta', is still the basis for making astronomical calculations, and for fixing up auspicious times for various rituals and preparation of *panchangs* (Hindu calendars).

He left his mortal coil around 550 A.D.. A lunar crater was named Aryabhatta in his honour.

India's first satellite was named Aryabhatta as a tribute to his contributions to astronomy and mathematics. Weighing 360 kg, it was put in orbit on 19th April, 1975.

□□

BARBARA MCCLINTOCK

(1902 - 1992 A.D.)

GENIUS GENETIST

In the first half of twentieth century, Genetics as a discipline had not yet received general acceptance. Relatively few students took this course and most of them were interested in pursuing agriculture as a profession. But she attended the only course in Genetics open to undergraduate students at Cornell University in the fall of 1921.

Soon after she completed the course in January 1922, she received a telephone call from Dr. Hutchison, a Professor in the Department of Plant Breeding, College of Agriculture, inviting her to participate in the only other genetics course available at Cornell.

Barbara recalled:

"His invitation was accepted with pleasure and great anticipations. Obviously, this telephone call cast the die for my future. I remained with Genetics thereafter."

Chromosomes then became a source of fascination for her. She took up scientific research in virgin maize fields at a time when any research was considered beyond women's capabilities. She faced incredible scientific and personal

challenges and established herself among the great scientists with her academic independence, originality, and extraordinary accomplishment.

Barbara McClintock was born on 16th June, 1902 in Hartford, Connecticut to Thomas Henry, physician and Sara Handy. On completion of her secondary education at Erasmus Hall High School in Brooklyn, her mother asked her to give up her studies as she disliked further education for her daughters. She feared that marriage for a well-educated daughter could be difficult, just like it was the commonly held belief in India uptill a few years ago. Her father thought better of her and McClintock completed her B. Sc. in Botany in 1923 at Cornell's College of Agriculture in 1919. She received her M.A. and Ph.D in 1925 and 1927 respectively. McClintock was leading studies on the new field of Cytogenetics, developing ways to visualise and characterise maize chromosomes and changes during reproduction. Her discoveries in many fundamental genetic ideas were pioneering and path-breaking.

With post-doctoral fellowships from the National Research Council, she continued her studies at Cornell and the California Institute of Technology. At the University of Missouri, Columbia, Geneticist Lewis Staler introduced her to the X-rays resulting in the identification of ring chromosomes. Armed with a fellowship from the Guggenheim Foundation, she received training in Germany during 1933 and 1934. In 1936, she returned to the University of Missouri as an Assistant Professor. Her researches on the effect of X-rays on maize Cytogenetics are an area of interest in cancer research even today.

In December 1941, she joined Cold Spring Harbour Laboratory of the Carnegie Institution, Washington on an invitation, where her experiments reached a new high. With the cellular analysis of genetic phenomena in corn, she revealed, for the first time, a visual link between inheritable traits and their physical basis in the chromosome. She demonstrated

chromosomes as the bearers of heritable factors which carry genetic information from one generation of maize plants to the next. McClintock discovered transposition, how genes turn physical characteristics on or off. She was the third woman to be elected to the National Academy of Sciences and in 1945, she became the first woman President of the Genetics Society of America.

She received puzzlement, even hostility, from most of her contemporaries and from 1953 she stopped publishing her research. But she continued her studies, for she knew:

"If you know you are on the right track, if you have this inner knowledge, then nobody can turn you off, no matter what they say."

In 1957, she explored the chromosomal, morphological, and evolutionary characteristics of rich varieties of maize in South America, thanks to the funding from the National Science Foundation, and the Rockefeller Foundation. She led a team working on South American maize at the North Carolina State University in Raleigh. After official retirement from the Carnegie Institution in 1967, she was retained as scientist emerita, a distinguished service member.

McClintock's research in Cytogenetics could be better understood only by the late 1960s and 70s, when researchers had new technological tools at their hands. Her personal feeling that when you know you are right, you don't care what others think and you know sooner or later, it will come out in the wash; was finally proved right.

She received National Medal of Science in 1971, Albert Lasker Award for Basic Medical Research, the Wolf Prize in Medicine, Louisa Gross Horwitz Prize from Columbia University and the Thomas Hunt Morgan Medal by the Genetics Society of America. In 1981, she became the first recipient of the MacArthur Foundation Grant. She was the recipient of fifteen honorary doctorates.

Nobel Prize for Physiology or Medicine was awarded to her in 1983 for discovering mobile genetic elements. Awarded after thirty years of her research, she is the first and only woman to receive an unshared Nobel Prize in that category. In 1986, she was inducted into the National Women's Hall of Fame. An anthology of her 43 publications, 'The discovery and characterisation of transposable elements: the collected papers of Barbara McClintock' was published in 1987.

Her mother's worst fears proved to be true as Barbara never got married. The lady, who hated sleeping, went into the eternal sleep at Huntington, New York, on 2nd September, 1992 at the age of 90.

"They called me crazy, absolutely mad at times," recalled Barbara McClintock.

Skeptical scientists questioned her findings and for decades denied their validity. Finally she was heaped with honours and material rewards at the age of 79. Then McClintock commented:

"These things never have been important to me. I never wanted to be bothered by possessions. When I was much younger, i used to say I wanted two things, i.e., to own an automobile and spectacles. Now I just want my spectacles. I never thought of stopping, and I just hated sleeping. I can't imagine having a better life."

□□

BENJAMIN PEARY PAL

(1906 - 1989 A.D.)

FATHER OF ROSES

"The gate of life swings to and fro,

And soon, too soon, it closes,

And that is why beside my door,

I grew red roses."

This quotation from the book 'The rose-Its beauty and science' is a vivid expression of his personal philosophy. His life was a combination of dignity, courtesy, compassion and love of beauty.

The man who saw science behind the beauty of roses is Benjamin Peary Pal. He was not only the Father of Roses but also was the harbinger of green revolution in India.

Though Peary Pal was born at Mukundpur, Punjab, on 26th May. 1906. He spent his early life in Burma. He was addicted to winning prizes and scholarships. He passed his M.Sc. in Botany from Rangoon University. In 1929, he left for Cambridge to do research on wheat. When he returned to Burma with a Ph.D five years later, he was appointed as Assistant Rice Research Officer at Central Rice Research Station at Himawbi.

In 1933, he came back to India as a second Economic Botanist at the Imperial Agricultural Research Institute at Pusa in Bihar.

He soon headed the botany division of the Institute which is now Indian Agricultural Research Institute in New Delhi. In 1950, he was appointed as the Director of the Institute. When Indian Council of Agricultural Research (ICAR) was reorganised in 1965, Dr Benjamin Peary Pal became its first Director General.

In the pre-independence and early post-independence days, there was not much accent on agricultural research in India. A multitude of various diseases destroyed the crops and the country had to depend on imports from affluent countries to feed hungry mouths.

Pal enters such a scenario. Rice and wheat are the staple diet of the country and Pal made a mental mission to develop new varieties of wheat which could resist diseases. He gave a clarion call to search for new genes. He started his researches for new genes and combination of the old and new genes. The outcome was new breeds NP (New Pusa) 700 and NP 800 series, which could resist a certain type of rust, a common form of disease killing wheat crops.

He was not satisfied. After eighteen long years of conscientious research NP 809 was planted in 1954. It was a major breakthrough as this variety could combat all three types of rust and the curtain rose for the Green Revolution. There was applause all over the world for the achievement of unassuming Indian scientist. That was not the end. He made extensive researches in potato and tobacco.

Benjamin Peary Pal was never married though he is known as the Father of Roses. He liked to be remembered as a bachelor wedded to the roses. With his unparalleled works, he bred some of the most beautiful varieties of roses named as - Dr. Homi Bhabha, Delhi Princes, Apsara, Banjaran, Dilruba, Homage etc. He developed about forty varieties of roses. One of his most popular books is 'The Rose in India'. He was a founder member of Rose Society of India and remained its President for several years.

Awards and acclaim poured in with the Rafi Ahmed Kidwai Prize, the Birbal Sahni Medal and the Ramanujan Medal, IRF Gold Medal, Sir William Jones Medal and Sanjay Gandhi Memorial Award. He was elected Fellow of the Royal Society in 1972. He was the member of Education Commission of India and first Chairman of the Government of India's committee on Environment. He was also the President of Indian Botanical Society, Horticultural Society of India, Indian Society of Genetics and Plant Breeding. He was the president of Indian National Science Academy. However, nothing can match the admiration he received from the farmers.

In 1946, he created a Plant Exploration and Collection Unit within IARI. It is now an independent ICAR Bureau, the NBPGR, holding the 4th largest collection in the world. He has over 160 scientific publications and five books to his credit.

As a role model for the scientific community, he brought research from labs to farms. For over three decades, he shaped the course of research and strengthened educational infrastructure. More than 30 scientists were awarded Ph.D under his guidance.

He was wedded to wheat, roses, bougainvillea and painting. The red roses, he grew beside his door must have cried on 14th September 1989, when he left them.

At an early age, Benjamin Peary Pal was introduced to plants. His father, though a physician, spent his spare time growing flowers and vegetables in their garden. Once when he was tired he asked teenaged Pal to look after the garden. Pal not only began to take care of the plants but also started improving them after reading books on gardening and seed catalogues. Plants became his lifelong friends. Even in his seventies, he took care of them with as much affection as he did when he was a boy.

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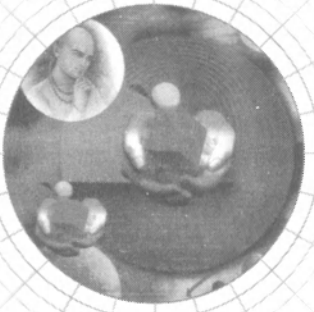
BHASKARACHARYA

(1114 - 1185 A.D.)



MATHEMATICIAN AND ASTROLOGER

He was a great astrologer. But he looked worried now. He calculated the horoscope again and again, but the answer remained the same. The death of his future son-in-law was imminent. He would die soon after the marriage.

But wasn't there a way out?

Yes!

The wedding should consummate at the exact auspicious date and time, sumuhurtam (most favourable date and time) and no chances to be taken. Mechanical or digital clocks were not invented then. So he built a small sand clock, in which sand would flow from the top vessel into a bottom vessel through a small aperture. The level of sand in the bottom vessel indicated the time. He sternly warned all his students not to go anywhere near the clock.

But inquisitive as she was, his daughter, Lilavati leaned over the sandglass, when a pearl from her necklace fell into the clock. The hole was partially blocked. Not knowing the mishap with the clock, the astrologer followed it and celebrated the marriage. But the divine clock worked without mistake and he lost his son-in-law soon.

To comfort his bereaved daughter, he taught arithmetic to her. He named his book after her, as 'Lilavati' where arithmetic flowed as poetry.

He was Bhaskaracharya, the most distinguished mathematician and astrologer of ancient India.

Bhaskara was born in 1114 A.D. at Bijjada Bida, the present-day Bijapur in Mysore. Bhaskara represents the heights of mathematical and astronomical knowledge in India during 12th century. His understanding of Mathematics was vast and far ahead of the rest of the world by several centuries.

His main works were 'Lilavati' (arithmetic) and 'Bijaganita' (algebra). His book 'Siddhanta Shiromani' was written in the year 1150 A.D. which consists of two parts: Goladhyaya (sphere) and Grihaganita (mathematics of the planets).

Bhaskara laced a mathematical problem into realistic story or incident and dressed it in a beautiful Sanskrit poetry. Maths was never presented in a more pleasant and lovely fashion before Bhaskaracharya.

Here is a sample from Lilavati:

(O girl! Out of a group of swans, 7/2 times the square root of the number are playing on the shore of a tank. The two remaining ones are playing with amorous fight, in the water. What is the total number of swans?)

'Lilavati' is divided into 13 chapters with 278 verses. It covers almost all the branches of mathematics, such as arithmetic, algebra, geometry, trigonometry and mensuration. Tables, the number system, and its operations like addition, subtraction, multiplication, division, square, cube, square root and cube root, fractions, zero, interest, progressions, geometry, mensuration, and permutations are all dealt with thoroughly.

'Bijaganita' (algebra) contains 213 verses. It describes rules to deal with

calculations of zero and infinity, and the concept of negative and positive numbers. It was Bhaskara, who decided that any other number divided by zero, yields infinity. Bhaskara dealt with differential calculus, quadratic equations and surds. Bhaskara derived a cyclic, chakravala method for solving indeterminate quadratic equations and Pell's equation.

'Siddhanta Shiromani' shows his knowledge of infinitesimal calculus and mathematical analysis, trigonometry, differential calculus and integral calculus. Bhaskara's principles of differential calculus are ahead of Newton by five centuries.

'Goladhyaya' deals with circles and spheres. It has chapters on spherical trigonometry, ellipse calculations, cosmography, geography and planetary motion. His other books are Vasana Bhashya (commentary on Siddhanta Shiromani), Karana Kutuhala (astronomy) and Vivarana.

He was the first mathematician to declare $a/0 = \mu$ (Infinity) and $\mu + a = \mu$.

He gave value for the ratio of the circumference to the diameter:

"When the diameter of a circle is multiplied by 3927 and divided by 1250, the quotient is the near circumference."

He gave formulae for the area and volume of the sphere as follows:

"In a circle one quarter of the diameter multiplied by 4 is the net all round of the ball. The content or surface of the sphere multiplied by the diameter and divided by 6 is the precise solid or cubic content within the sphere."

Earlier, Aryabhatta had proposed heliocentric solar system of gravitation where the planets follow an elliptical orbit around the sun, and Brahmagupta propounded the law of gravity. Bhaskara based his calculations on these theories. For instance, for the sidereal year (the time taken for the Earth to orbit the sun) his figure was 365.2588 days against

the present measurement of 365.2596 days, an error of just one minute. One wonders how he calculated extremely accurate astronomical values without the aid of sophisticated instruments.

Bhaskaracharya also discusses solar and lunar eclipses, conjunctions of the planets with each other and with the fixed stars, mean and true longitudes and latitudes of the planets and moon's crescent.

He served as the head of the astronomical observatory at Ujjain. It is now well known that Bhaskaracharya influenced mathematical developments in Europe and the Middle East.

Bhaskara-I and II are the two satellites named after Bhaskaracharya. They were built by the Indian space program that formed India's first low orbit Earth Observation Satellite to collect the data on telemetry, oceanography and hydrology.

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C. N. R. RAO

(1934 A.D...)

MATERIAL CHEMIST

The school exams were just over. The students did better than he thought. The wise teacher was impressed and thought that he should impart more knowledge to them. The teacher took them over for a meeting with the Noble Prize winner, Prof. C. V. Raman. Raman spared his valuable time to talk about physics for over three hours and showed them around his lab. That incident spurred interest in an 11-year-old boy which became a life long passion for him.

Let's now move on to the inaugural session of the 93rd Indian Science Congress in 2004.

Dr. Manmohan Singh, the Prime Minister of India, presented the first India Science Award to the world's foremost solid state and materials chemist.

He was the same boy.

But that was just one more award in his awards kitty. He was already awarded Marlow Medal of the Faraday Society in 1967, the Jawaharlal Nehru Fellowship in 1973, the Indian Chamber of Commerce and Industry Award for Physical Sciences in 1977, the Royal Society of Chemistry (London) Medal in 1981, the General Motors Modi Award in 1989, and the Hevrosky Gold Medal from the Czechoslovak Academy of

Sciences in 1989, the Hughes Medal by the Royal Society in 2000 and Dan David Prize in 2005, of Tel Aviv University. He received every other award except the Nobel Prize. But he did not work for awards. He often said:

"Actually, doing science, rather than the results, is more exciting."

Chintamani Nagesa Ramachandra Rao was born on 30th June, 1934 to Hanumantha Nagesa and Nagamma in Bangalore. After his B.Sc from Mysore University, he got a master's degree from Benaras Hindu University in 1953. He earned his Ph.D from Purdue University, where he worked under Noble Laureate H. C. Brown on solid state chemistry. He studied the structure and phenomena in solids at the microscopic level using sophisticated tools of spectroscopy in his own lab at the university. Totally new types of solids with entirely new properties useful for the industries could be created because of his researches.

In 1958, he joined the University of California at Berkeley as a research chemist. He started his career back in India as a lecturer at the Indian Institute of Science in Bangalore in 1959. In 1960, he married Indumati. They have two children, Suchitra and Sanjay.

He served as a Professor of Chemistry at the Indian Institute of Technology in Kanpur from 1963-76 and as Head of the Chemistry Department from 1964 to 1968, and Dean of Research for three years. He was back at Indian Institute of Science, Bangalore between 1976-84 as the Chairman of the Solid State and Structural Chemistry Unit and Materials Research Laboratory. From then onwards, he has been the Director of the Institute of Science. He was a visiting professor at Purdue University in 1967-68, at Oxford University in 1974-75, and at Cambridge University in 1983.

Professor Rao's prolific researches in solid state and Materials Chemistry places him as one of the topmost figures on the subject. His works on transition metal oxides have shown

an unusual promise in room temperature superconductivity and magneto resistance. Superconductivity occurs when certain metals loose all their electrical resistance while carrying currents without any loss of energy. He published three books on these theories namely, 'Chemical and Structural Aspects of High Temperature Superconductors' in 1988, 'Bismuth and Thalium Cuprate Superconductors' in 1989, and 'Chemistry of High Temperature Superconductors' in 1991. Rao has written 37 books and over seven hundred research papers.

Rao received honorary doctorates from many universities. Some of them are - Purdue University in 1982, Bordeaux University in 1983, and Wroclaw University (Poland) in 1989.

For two years, 1985-87, he presided over the International Union of Pure and Applied Chemistry (IUPAC). IUPAC serves to advance the worldwide aspects of the chemical sciences and to contribute to the application of chemistry in the service of mankind. He was a founding member of the Third World Academy of Sciences. He is a Fellow of the US National Academy of Sciences, American Chemical Society, the Royal Society, Slovenian Academy of Sciences, Serbian Academy of Sciences, American Academy of Arts and Sciences, Russian Academy of Sciences, Czechoslovak Academy of Sciences, and Polish Academy of Sciences. He is currently the Chairman of the Science Advisory Committee to the Prime Minister.

He received Padma Vibhushan Award from the President of India in 1985.

In 2005, the French Government conferred the title Chevalier de la Legion d'Honneur (Knight of the Legion of Honour), its highest civilian award on him.

Even at the age of seventy-two, his obsession for science has not diminished. Presently he is working on nano-materials. These materials particularly carbon nano-tubes which are thinner than human hair have great promises for future in every field of human activity. Prof. Rao says:

"Though our generation might not see the fruits of Nanotechnology, I have been pursuing this. I want India to be in the forefront of nano-sciences."

Seeing the present state of research in India, and over-emphasis on IT, he lamented, "The day may not be far when your child asks you to meet a distinguished scientist in Bangalore, and we have to direct him to the Vishweswarayya Institute of Technology Museum."

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"You cannot be industrially and economically advanced unless you are technologically advanced, and you cannot be technologically advanced unless you are scientifically advanced."

C. R. RAO

(1920 A.D...)

RAO THEOREMS

Year - June 1940, World War II.

Journey - Arduous train journey of 850 km from Vishakapatnam to Calcutta (now Kolkata).

Age - Not yet twenty.

Aspirations - A job in the military.

Qualification - First -class degree in mathematics.

Result - Not lucky.

Reason - Too young for the job.

Twist of fate - The same young fellow walks down the corridors of the Indian Statistical Institute (ISI) founded in 1931. He submits an application for one-year training program in statistics. Much to his delight, he receives an admission letter from the founder Professor Prasanta Chandra Mahalanobis. The young man never looked back and is probably the most well known statistician in the world today.

Calyampudi Radhakrishna Rao was born on 10th September 1920 in Huvvina Hadagalli, Karnataka to C.D. Naidu and A. Laxmikantamma. As the family settled down in Vishakhapatnam, Andhra Pradesh, he joined A.V.N. College for the Intermediate course. By the time he passed his M.A. exam

in 1943 from Andhra University, he had already published many research papers. He got his gold medal, nevertheless. Then he joined Indian Statistical Institute.

After three years at ISI and at Calcutta University, he was deputed to the Cambridge University on a project in 1946. He completed his Ph.D under R.A. Fisher, the father of modern statistics. Statisticians all over the world were wonderstruck in 1945 when he presented his Theory of Estimation. Many of the formulae and theorems in statistics started bearing his name, some of them Cramer-Rao Inequality, the Fisher-Rao Theorem and Rao-Blackwell Theorem, Rao's score test and Rao's orthogonal arrays. In 1965, he collaborated with R. A. Fisher on a genetics problem. He mapped chromosomes in mice using statistics.

Professor Rao got married to Bhargavi Rao on 9th September, 1948 and has two children. Back at ISI, he was made a Professor in 1949 at the very young age of 29, and soon became a Fellow for his outstanding contributions in statistics. He went on to become the Director of the ISI and the editor of the magazine Sankhya in 1972.

He calls statistics a very human science:

"If there is a problem to be solved, seek statistical advice instead of appointing a committee of experts. Statistics can throw more light than the collective wisdom of the articulate few."

Truly, his researches in Inference & Linear Models, Multivariate Analysis, Combinatorial Designs, Biometry, Mathematical Genetics, Generalized Inverses of Matrices, and Functional Equations find applications in almost every branch of science. Orthogonal arrays help the industry in increasing production to the maximum. His contributions in multivariate analysis are used in medical diagnosis, plant breeding. Biometry is a tool for the mathematical study in biology. His statistical methods are applied in anthropology. It is an accepted fact that his early work had greatly influenced the course of statistical research during the last four decades.

He left ISI in 1978 and joined the University of Pittsburgh. In 1988, he held the Eberly Family Chair in Statistics at the Pennsylvannia State University and the Directorship of the Centre for Multivariate Analysis till 2001.

Dr. Rao is a Fellow of the Royal Society of London, and a member of the National Academy of Sciences, U.S.A. He was awarded the Padma Vibhushan in 2001. The C.R. Rao Award for Statistics was instituted in his honour, to be given once in two years. The Advanced Institute of Mathematics, Statistics and Computer Science in the Osmania University Campus has been named after him. At the last count, he has received as many as 32 honorary doctoral degrees from universities around the world, and at least 50 students received Ph.D degrees under his guidance. Professor Rao has authored 14 books and about 350 research papers.

Awards and medals he received are too many to be counted but some of them are - National Medal of Science from President Bush, Guy Medal in Silver of the Royal Statistical Society, Megnadh Saha Medal of the Indian National Science Academy, S. S. Bhatnagar Award, JC Bose Gold Medal of Bose Institute, Mahalanobis Centenary Gold Medal of the Indian Science Congress, Samuel S. Wilks Medal in 1989 and the Distinguished Achievement Medal from the ASA in 1997.

The ASA Pittsburgh Chapter named Rao as its 'Statistician of the Year' in 1981. Rao is a foreign member of at least eight national academies in the world and honoured as Fellow of another 26 scientific organisations.

The Times of India chose this living legend as one of the top ten scientists of modern India. Penn State University has established C. R. and Bhargavi Rao Prize in statistics.

13th May was proclaimed as 'C.R. Rao Day' by the Mayor of Kent in 2000, who also presented Dr. Rao with a key to the city.

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CHARLES GOODYEAR

(1800 - 1860 A.D.)

VULCANISATION

Napoleon III awarded the 'Cross of the Legion of Honour' to this scientist. Surprisingly, it had to be presented to him in the prison where he was thrown in for non-payment of debts.

But then, some of his first experiments were carried out in the jail itself. His wife brought pieces of raw rubber and her rolling pin to the cell, where he was incarcerated. Kneading and rolling for hours and adding bit of magnesia, he produced nice white compound that seemed to solve all the problems for the time.

Once he went to Boston to meet some friends, but could not meet any one. Back at the hotel, he was booked and jailed for non-payment of a $5 hotel bill. On returning home, he found his infant son dead. No money to pay for a funeral, he himself carried the little coffin to the graveyard.

On 1st July, 1860, he reached New York to see his dying daughter, only to find that she was already dead.

This is the saga of a man who showed almost superhuman perseverance in his search for a stable rubber and in the process developed the vulcanization of rubber. Goodyear did not invent rubber but discovered a process to make it more stable, and as versatile as it is now. Without

vulcanization it was a saggy, shapeless sticky paste. His life is a saga of failures and penury. He was frequently thrown in jail and was scoffed at his invention. When it became finally successful, it was stolen. He did not cry, as he felt:

"A man has cause for regret only when he sows and no one reaps."

Charles Goodyear was born in New Haven, Connecticut on 29th December, 1800. He was the son of Amasa Goodyear. In 1816, Charles left his home to Philadelphia and returned to join his father's manufacturing business of ivory, metal buttons and agricultural implements. In August 1824, he married Clarissa Beecher who was a pillar of strength and stood by him through his travails.

Two years later, he opened a hardware store in Philadelphia. He suffered bad health and the business was on the brink of bankruptcy. But material known as gum elastic, a rubber, caught his eye and he dug out every piece of available information on it. He started developing articles with that material.

In the summer of 1834, he walked into a retail store in New York of the Roxbury India Rubber Co., America's first rubber manufacturer and showed the store manager a new valve he made. Silently the manager took him inside and showed him a display of racks and racks of rejected materials. Goodyear was disappointed but not dejected. Taking a good look at rubber, he thought:

"There is probably no other inert substance, which so excites the mind."

As soon as he returned to Philadelphia, Goodyear was thrown into jail for bad debt. While in the jail, he rolled magnesia with the rolling pin into the material brought by his wife. Beautiful white compound appeared which seemed to solve the problem.

Soon out of jail, Charles, his wife and small daughters made a number of rubber shoes with that new formula in their kitchen. But came summer and the shoes sagged into shapeless mass. He was thrown out his house for obnoxious smells. His brother-in-law gave him a dressing down advising him to feed hungry children first and forget the *dying* rubber. Goodyear answered him, "I am the man to bring it back."

He went on experimenting, making it better, even making decorated models with it. A New York trade show awarded him a medal. When nitric acid was applied on a decoration piece to remove the bronze coating, it turned out to be better than all others made so far. He received several thousand dollars as advance by a New York businessman for the new development. But the great depression of 1837 promptly wiped all of them out.

Goodyear got a government order for 150 mailbags, to be manufactured by this new nitric-acid process. He lived in a temporary glory, made them and went on holiday. When he returned, the mailbags were mass of sticky gum. His process failed. His children were back in the backyard digging half-grown potatoes for food.

His greatest day came in the winter of 1839. The discovery is often mentioned as one of the most famous accidents resulting in a scientific discovery. There is story that he rubbed a little sulfur on a piece of rubber and forgot it overnight. There is a story that he threw a piece of rubber in a store and it fell on a hot stove. A major breakthrough occurred by heating natural rubber and sulphur, the process known as vulcanization, named interestingly by a rival after Vulcan, the Roman god of fire.

By 1844 he perfected the process sufficiently and factories were started at Springfield and Naugatuck. He lived with rubber and made every conceivable product with it like banknotes, musical instruments, flags, jewelry, rubber hats, vests, and ties. At the world's fairs in 1850s, both in London and Paris, Goodyear built pavilions entirely of rubber, floor to roof. But that did not

bring riches to him or place him in the high corporate profile. Instead he pawned everything in his household including his watch and crockery. He did make rubber crockery, but where was the food?

And then there are patent robbers. He had to prosecute 32 infringement cases right up to the US Supreme Court. He made headlines, but not money. His French patent was cancelled on technical grounds; he was bundled off for a 16-day and night free stay at his well-known 'hotel' as he called it, the prison. He had $200,000 debt, when he died, in 1860. However, royalties from his inventions made his family comfortable.

His final words were:

"Life should not be estimated exclusively by the standard of dollars and cents. I am not disposed to complain that I have planted and others have gathered the fruits."

We are now enjoying the fruits of his rubber with their myriad varieties and uses in every walk of our lives.

On 8th February, 1976, he was selected for induction into the National Inventors Hall of Fame. An elementary school was named after him in his hometown of Woburn, Massachusetts.

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CHARLES H. TOWNES

(1915 A.D....)

LASER

On the early morning of 26th April 1951, a physicist was walking his way to a conference in Washington D.C. with an unsolved problem in his mind. For a moment, he felt like sitting on the Franklin Park bench, where the idea dawned on him how light could be corifigured into a very pure form. He pulled an envelope out of his jacket and started jotting down the calculations. The result was the MASER (Microwave Amplification by Stimulated Emission), which amplifies microwaves to produce an intense beam and the development of LASER (Light Amplification by Stimulated Emission). Writing parallels between religion and science, later on, the physicist Charles Townes wrote:

"There is a tremendous emotional experience in scientific discovery which I think is similar to what some people would normally describe as a religious experience, a revelation."

Charles Hard Townes was born in Greenville, South Carolina, on 28th July, 1915, the son of Henry Keith Townes, an attorney, and Ellen Townes. He attended the Greenville Public School and then Furman University in Greenville, where he completed the Bachelor of Science degree in Physics and the Bachelor of

Arts degree in Modern Languages, at the age of 19. The beautifully logical structure of physics fascinated him.

Townes received his master's degree in Physics at Duke University in 1936 and the Ph.D from the California Institute of Technology in 1939 with a thesis on isotope separation and nuclear spins.

Joining Bell Labs, Townes helped develop a radar system with a 1.25 centimeter wavelength. Townes designed radar bombing systems during World War II resulting in a number of patents. At Columbia University, as Associate Professor of Physics in 1948, he turned research in microwave physics, to study of the interactions between microwaves and molecules, and microwave spectra for the study of the atomic structure. In 1951, the idea of the maser was dawned interestingly on a Franklin Park bench. After three years of exhaustive experiments, Townes and Jim Gordon created a working maser.

Townes served as Executive Director of the Columbia Radiation Laboratory from 1950 to 1952 and was elected Fellow Member of the National Academy of Sciences in 1956. With Arthur Leonard Schawlow, he wrote the book 'Microwave Spectroscopy' published in 1955.

In 1958, Dr. Townes and his brother-in-law, Dr. A.L. Schawlow, presented their joint paper on optical and infrared masers (microwave amplification by stimulated emission of radiation) or lasers (light amplification by stimulated emission of radiation). In pioneering researches in radio and infrared astronomy, his team detected the first complex molecules in interstellar space and first measured the mass of the black hole in the center of our galaxy.

From 1959 to 1961, he served as Vice President and Director of Research of the Institute for Defense Analyses in Washington, D.C., a nonprofit advisory to the U.S. government. He was the Chairman of the Advisory Committee for the first human landing on the moon, and Chairman of the Defense Department's

Committee on the MX missile. He also served on the boards of General Motors and of the Perkins Elmer Corporations. Awards and recognitions he received are just too many to be counted. He had 27 honorary degrees from various Universities.

In 1964, he was awarded the Nobel Prize in Physics along with N. G. Basov and Aleksandr Prokhorov for contributions in Quantum Electronics leading to the development of the maser and laser. Templeton Prize for progress towards research or discoveries about spiritual realities was awarded to him in 2005.

He was awarded the Niels Bohr International Medal for contributions to the peaceful use of atomic energy in 1979 and in 1982. He also received the National Medal of Science, presented by then President Ronald Reagan. In 2000, the Russian Academy of Science awarded him the Lomonosov Medal. In 2006, Townes and his associate Raj Reddy received the Vannevar Bush Award for Lifetime Contributions and Statesmanship to Science.

Townes married sister of his fellow researcher Dr. Schawllow. They have four daughters.

During his time at Bell Labs, Townes was asked to help with the development of a new radar system for aircraft in World War II. He never served in the military, but felt he was helping his country from within the lab. Townes and his team were successful in creating more accurate and precise radar systems, but none of them were ever mass produced by the military.

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CHARLES KETTERING

(1876 - 1958 A.D.)

AUTOMOBILE INVENTIONS

The present generation must have seen those jaunty jalopies only in the good old movies of Charlie Chaplin era. Insert a hand crank into the engine. Use all your strength and turn it. When the engine makes a phut phut start, remove the handle real fast or else it may hit back on the face or the car may roll forward. Run away! The car has no brakes! Not yet!

Enter Charles Kettering and hand cranking soon became a history. Cadillac built on 17th February, 1911, was the first automobile to have a self starter. Automobiles were never the same again.

Kettering earned his first $14 by working as a labourer in a wheat farm. He bought a telephone with that money, and dismantled it, only to know how it works. But then, from that curiosity corner, there began a career credited with about 140 patents. His philosophy was:

"It doesn't matter if you try and try and try again, and fail. It does matter if you try and fail, and fail to try again."

Loundonville, Ohio was fortunate to be the birthplace of Charles Franklin Kettering who was born to Jacob and Martha on 29th August, 1876. After high school education; he took up a job

of a teacher in a one-room rural school. In 1896, he left the teacher's post to study at College of Wooster (Ohio), only to return back soon enough due to deteriorating eyesight. Intense desire for education brought him back in 1898 to an engineering school at Ohio, but again his poor eyesight took its toll. For next two years he earned living by repairing telephone lines. Nevertheless he finished his electrical engineering degree in 1904.

After graduation, Kettering joined the National Cash Register Company (NCR) in Dayton, Ohio. He proved his mettle and soon the company was richer when he developed cash registers with electric motors; equipped their department stores with the OK-Charge phone, and other improvements.

Kettering married Olive Williams in 1905 and their only child, Eugene Williams Kettering, was born on 20th April, 1908. His son fully inherited his father's traits.

In 1909, Kettering along with Edward A. Deeds established an industrial research laboratory, the Dayton Engineering Laboratories Company (DELCO), where he went on to invent the self starter, automotive lighting, special lacquer paint and leaded petrol for cars.

His first love was teaching and he was a proponent of the concept of practical education. He felt that people learned not only with their minds, but with their eyes and ears and hands.

Speaking on an occasion in 1916, he observed:

"Modern psychology teaches that experience is not merely the best teacher, but the only possible teacher. There is no war between theory and practice. The most valuable experience demands both and the theory should supplement the practice and not precede it."

His concepts culminated in the Flint Institute of Technology in 1919 and the General Motors Institute in 1926 (now Kettering University). Speaking at the General Motors Institute in August 1932, Kettering said:

"I think that the greatest education in the world is the education which helps one to be able to do the right things at the time it has to be done."

When General Motors bought DELCO in 1920, Kettering became Vice President for the General Motors Research Corporation. He was nicknamed 'Boss'. He believed:

"An inventor fails 999 times, and if he succeeds once, he's in. He treats his failures simply as practice shots. The opportunities of man are limited only by his imagination."

Unlike Edison's list, we do not have a count of his practice shots here but the list of his inventions are unending: shock absorbers; safety glass; automatic transmission; the electric railway gate; etc. You will be wrong if you think Kettering invented things for automobiles alone. He developed the first synthetic aviation fuel. He invented Freon as refrigerant for refrigerators and air conditioners. Kettering's Dayton home, in fact, was the first in the country to be air-conditioned.

He developed light weight diesel engines locomotives. First of a 600HP engine was fitted on to 'Pioneer Zephyr' train on the Chicago, Burlington and Quincy Railroad.

He was first to apply magnetism as a medical diagnostic tool. He developed a treatment for venereal disease; an incubator for premature infants and artificial fever therapy. The outcome of his interest in medical diagnostics is the establishment of the Sloan-Kettering Institute in New York, in 1945, a premier cancer research facility.

He retired from General Motors Research in 1947. He said:

"My interest is in the future because I am going to spend the rest of my life there."

But his future was shortlived. Kettering survived a series of strokes but finally succumbed to one on 24th November, 1958.

Kettering built a home, Ridgeleigh Terrace, in 1914. His house was the first home in the United States to have electric air conditioning.

CHESTER CARLSON

(1906 - 1968 A.D.)

PHOTOCOPY MACHINE

Want a copy? Put your paper in the machine, close the door, press a few buttons. Get it in black and white or in colour, enlarge it or reduce it. Presto! Copy slides out! People even forgot calling it a photocopy, routinely call it as Xerox! But the man who invented it had to run from pillar to post begging authorities to take it.

Chester Carlson was rejected by at least 20 companies including IBM, General Electric, and RCA. Disgusted with his experiments in the kitchen, his wife left him. His trusted assistant, with whom he made the original copying experiment, left him for greener pastures. After seven long years of rejections, finally a tiny company in New York, the Haloid Company, purchased the rights to his invention, an electrostatic paper-copying machine, which revolutionised offices. That company is now Xerox.

But who is Carlson? He has been granted 34 United States patents, of which 28 relate to xerography. Finally when he earned, he donated more than $100,000,000 to charitable causes out of $150,000,000. He was a devotee of the Indian sage Ramakrishna Paramhansa and donated money for the Vedanta Center in Chicago.

Chester F. Carlson was born on 8th February, 1906 at Seattle, Washington. His mother died of tuberculosis when he was 17. His father also suffered from severe tuberculosis, and died when Carlson was 21.

Due to family conditions, poverty and isolation, Carlson was forced to take up work after school hours at an early age. Carlson once said:

"Work outside of school hours was a necessity at an early age. I had read of Edison and other successful inventors, and the idea of making an invention appealed to me as one of the few available means to accomplish a change in one's economic status."

Still he got his B.S. degree in Physics in 1930 at the California Institute of Technology. All the 82 companies where he applied for a job rejected his application.

He joined the Bell Telephone Laboratories in New York as a Research Engineer at $35.00 per week. But in about three years of employment he walked down the streets again, unemployed with thousands of other men. He was laid off in 1933, during the Great Depression. After repeated trials, he finally landed a job in a patent attorney's office near New York City's Wall Street. After a year, he joined P. R. Mallory Company (now Duracell), where he was promoted to head of the patent department.

By 1935, he was more or less settled, but the life was still hand to mouth. It was a hard struggle for existence. In 1936, he began to study law at night at New York Law School and received his Law degree in 1939.

During the course of his patent work, he thought of a small copying machine into which one could feed the original document and get a finished copy in a few seconds. It is not that there were no copying machines available. They were expensive and unwieldy. He started studying the possibilities and one day in the library, he came across a book on 'Electrostatics.' A whole new horizon was opened up with a new inspiration.

Photoconductivity, discovered by the Hungarian physicist Paul Selenyi, caught his attention. From basic concept, Carlson refined and re-refined the idea so much that he filed a preliminary patent application on 18th October, 1937.

Then near-disaster struck.

Just like his father, he also developed severe arthritis of the spine. He feared total disability and felt discouraged. But Carlson was not one to give up so easily. He was sure to change adverse conditions to his advantage. He said:

"In some ways, this situation also served as an added inducement to produce a marketable invention."

In his small, one room apartment in Astoria Queens, New York City, he turned his kitchen into his laboratory. Carlson's experiments became very unpopular around the house. One evening during an experiment, sulphur caught fire and filled the house with fumes. A young woman named Dorris came over into the kitchen after this incident and gave her piece of mind to him. Soon after they were married, of course!

He took the help of Otto Kornei, an immigrant physicist in his experiments. 22nd October, 1938, was a historic occasion. Carlson wrote the words "10-22-38 Astoria" on a slide with India ink. He placed it on top of a zinc plate coated with sulfur. The room was darkened. The sulfur was charged by rubbing with hand kerchief and was lit with a bright light for a few seconds. Then the sulfur surface was covered with spores of fungus, lycopodium. When the fungus was blown off, there it was - an almost exact mirror image. The image was preserved with a wax paper.

It sounds amazing but that was the beginning of disappointment and frustration for Carlson. Every single company rejected his invention. Finally turning point came when in 1944 he came into contact with Battelle Corporation, a non-profit organisation devoted to sponsoring new inventions. Battelle soon got the Haloid Company to further develop the

concept. Exactly ten years after Carlson's first successful experiment, the Battelle and Haloid made the first public announcement of Xerography on 22nd October, 1948. A professor suggested the name Xerography from the Greek words 'xeros' for dry and 'graphos' for writing. Haloid officially changed their name to Haloid Xerox, and finally to Xerox in 1961.

Carlson left us with his photocopies on 19th September, 1968.

Chester Carlson once came up with the idea of inventing a ball-point pen, but dropped it as he thought that it may not work.

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His original equipment along with the first xerographic print are on display at the Smithsonian Institution, He presented them to the institution in 1965 on the commemoration of the 175th anniversary of the U.S. patent system.

E.C.G. SUDARSHAN

(16th September, 1931...)

TACHYONS

Nobel committee ignored fundamental contributions made by an Indian scientist and awarded the Nobel Prize in Physics for 2005 to Roy J. Glauber. Sudarshan was disregarded who did decisive work on the subject. International scientific community was surprised at this omission and many scientists wrote to the Swedish Academy, protesting that Sudarshan should have been awarded a share of the Prize for the Sudarshan-Glauber representation (or Sudarshan diagonal representation) in Quantum Optics.

Reacting sharply to the Nobel Committee, finally E.C.G. Sudarshan protested in a letter. Here is an excerpt from the letter sent to the Nobel Committee:

"In the announcement of the 2005 Physics Nobel Prize, the Swedish Royal Academy has chosen R.J. Glauber to be awarded half of the prize. The prize winners are chosen by the Royal Academy, but no one has the right to take my discoveries and formulations and ascribe them to someone else!"

In his letter to the Nobel committee, he further asked:

"... The irony of the situation is that in spite of all these facts being available in print, the diagonal representation instead of being referred to as the Sudarshan representation

is dubbed as either the P-Representation (as if Glauber discovered and named it first) or at best as `Glauber-Sudarshan' Representation. It is my belief that the Royal Swedish Academy was impartial. It was also my belief that the members of the Committee did their work diligently and with care. I am therefore genuinely surprised and disappointed by this year's choice. Give unto Glauber only what is his."

Speaking to Hindustan Times later, he said:

"The 2005 Nobel Prize for Physics was awarded for my work, but I wasn't the one to get it. Each one of the discoveries that the Nobel was given for were based on my research."

But then it was not all. Nobel committee had also missed him earlier in 1979. Sudarshan asked a simple question:

"Steven Weinberg, Sheldon Glashow and Abdus Salam built on work I had done as a 26-year-old student. If you give a prize for a building, shouldn't the fellow who built the first floor be given the prize before those who built the second floor?"

There are instances in the history where Nobel Committee ignored eminent persons, classic case being Mahatma Gandhi. But here is a case where the prize was awarded to some one else for the work he did. And that happened twice in Sudarshan's case!!

Disproving Einstein theory that no particle can travel faster than light i.e., 300,000 km/second, he predicted the existence of tachyons, faster than light particles. When these particles were proposed, there was a furore in the scientific community. Many scientific journals refused to publish his findings.

Ennackal Chandy George Sudarshan (E.C.G. Sudarshan) was born on 16th September, 1931, Pallam, in Kottayam district of Kerala as the second son of E.I Chandy, a revenue Supervisor in Kerala Government and Achamma, a school teacher. He had his

early studies at C.M.S College, Kottayam. Sudarshan graduated from the Madras Christian College in 1951 and did his master's at the University of Madras in 1952.

During 1952–55 he was with Dr. Homi J. Bhaba researching on Cosmic Rays at TIFR. Then he went to University of Rochester, New York for his Ph.D studies with Robert Marshak. In 1959–1961, he was a Research Fellow at Harvard University. From 1962 onwards, he was on various teaching and research assignments at University of Rochester, Institute of Exact Sciences at the University of Berne, Professor of Physics, Syracuse University. From 1969 onwards, Sudarshan has been a professor at the University of Texas, Austin, United States. He is an American citizen since 1991.

He married Bhamathi, Professor and Head of Physics department at the University of Madras. He had been a senior Professor, Indian Institute of Sciences, Bangalore during 1973-1984. As the Director of Institute of Mathematical Sciences during 1984-1990, he transformed it into a center of excellence. It was an era when he had to adjust his time and life between India and America.

One of his important contributions (along with Robert Marshak) in Physics is the V-A theory of the weak force, which finally resulted in the Electroweak Theory. He is the originator of the Sudarshan-Glauber representation (Sudarshan diagonal representation), a quantum representation of coherent light.

Making use of this representation, he developed a theorem on the equivalence of classical Wave Optics to Quantum Optics. His prediction of tachyons (particles that can travel faster than light) was initially received with certain skepticism but now more and more scientific papers are pouring in. We now have virtually reached the technological limits of our speeds and Tachyons can really break the speed barrier resulting in real breakthroughs. He also proposed what is known as the Quantum Zeno effect along with Baidyanath Misra.

He received Padma Bhushan by President of India, in 1976. Among a host of other doctorates, he received D. Sc., Honoris. Causa, from Wisconsin in 1969. He won the First Prize in Physics by the Third World Academy of Sciences in 1985, Majorana Prize in 2006, Bose Medal in 1977, and CV Raman Award in 1970.

His favourite piece of general lecture is on Vedanta. He often quotes from ancient texts in his papers. Papers presented by him individually or with others run into few hundreds. Some of the books he authored and co-authored are 'A Gift of Prophecy: 'Essays in Celebration of the Life of Robert Eugene Marshak', Classical Dynamics : A Modern Perspective', 'Pauli and the Spin-Statistics Theorem', '100 Years of Planck's Quantum' and 'Fundamentals of Quantum Optics'.

E.C.G. Sudarshan is presently a Professor at the University of Taxas, Austin, United States.

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EDWARD JENNER

(1749 - 1823 A.D.)

VACCINATION

He hoped that someday the practice of producing cowpox in human beings will spread over the world - when that day comes, there will no more be smallpox.

His vision was fulfilled when the World Health Organization declared smallpox an eradicated disease. It was till then such a deadly unrelenting scourge which either killed or disfigured the affected ones. It took almost 180 years for man to conquer the disease with the medicine Edward Jenner had created.

Edward Jenner was born on 17th May 1749. He apprenticed under Dr. Ludlow for eight years at Chipping Sodbury, Gloucestershire. In 1770, he started working under Surgeon John Hunter, a Fellow of the Royal Society at St George's University of London. Hunter instilled in him the oft-repeated William Harvey's words, "Don't think, try!" which became the backbone of his researches. He began his medical practice by 1773 at Berkeley.

Jenner used to contribute papers on angina pectoris, and ophthalmia, etc., in the meetings of a medical society in Rodborough, Gloucestershire which he co-founded along

with his doctor friends. But he was derided when he suggested possibility of a connection between smallpox, cowpox and swinepox.

After he submitted a very careful description of little-understood life of the cuckoo in the nest, Jenner was elected Fellow of the Royal Society in 1788. In 1792, he received his MD from the University of St. Andrews. He believed:

"The deviation of man from the state in which he was originally placed by Nature seems to have proved to him a prolific source of diseases."

Was he alluding to the modern polluted world?

One day, in March 1788, one of his experimental balloons landed in the courtyard of Anthony Kingscote, where Jenner met Anthony's daughter, Catherine Kingscote. Later, he married her.

His keen observations showed him that milkmaids did not generally contract this dreadful disease, smallpox, though they often got infected by the pus from the blisters on the cows suffering from cowpox (a disease similar to smallpox, but much less dangerous). He hypothesised that this imparted certain immunity and protected the milkmaids from smallpox.

On 14th May, 1796, Jenner tested his theory on James Phipps, a young boy. He took pus from the cowpox blisters from the hand of Sarah Nelmes, a milkmaid. She caught cowpox from a cow called Blossom. He inoculated the boy with cowpox pus in both arms. The boy had a small fever but soon recovered without any serious illness. Jenner also did the same to his son, who, of course, died in a later outbreak. Jenner called his treatment 'Vaccination' from the Latin word 'vacca' (a cow). This word was adopted by Pasteur for immunisation against any disease.

Scientific community was as usual skeptical and the Royal Society did not publish his reports. He was quoted to have said:

"I shall endeavor still further to prosecute this inquiry, an inquiry I trust not merely speculative, but of sufficient moment

to inspire the pleasing hope of its becoming essentially beneficial to mankind."

With these thoughts in mind, he published a report of twenty-three cases with his own money. However, in 1806, British Parliament granted £30,000 to him for continuation of his work.

With his active involvement, Jennerian Institution was created in 1803, which became the National Vaccine Establishment by 1808.

In 1805, he was made a member of the Medical and Chirurgical Society of London, now the Royal Society of Medicine. In 1821, he was appointed as Physician Extraordinary to King George IV and was elected as the Mayor of Berkeley and Justice of the Peace. Royal Society published his article 'Observations on the Migration of Birds' in the Philosophical Transactions of the Royal Society in 1824.

He published a number of articles in his life time - in 1798, 'An Inquiry Into the Causes and Effects of the Variolæ Vaccinæ'; in 1799, 'Further Observations on the Variolœ Vaccinœ'; in 1800, 'A Continuation of Facts and Observations relative to the Variolœ Vaccinœ' and in 1801 'The Origin of the Vaccine Inoculation'.

His wife died in 1815. Jenner died on 26th January 1823 after the second stroke. He was survived by a son and a daughter.

His house at Gloucestershire is now a small museum where the horns of the cow Blossom are on display. St Georges University, London named a wing after him, where the hide of the cow Blossom is displayed in the medical school library.

In 1813, Edward Jenner's name was proposed for the prestigious College of Physicians in London. But he had to pass a test. However his name was rejected as Jenner refused to take the test.

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FELIX HOFFMAN

(1868 - 1946 A.D.)

ASPIRIN AND HEROIN

Now this drug is routinely prescribed for preventing heart attacks and for reducing the risk of death during a suspected heart attack. Ironically, the drug was initially rejected under the plea that it made the heart feeble.

The scientist's second discovery was Diacetylmorphine. Drugs were tested in those days on the workers using them as human guinea pigs. They felt heroic after taking this drug. Hence it was called heroin.

The scientist was Felix Hoffmann who synthesized within a two-week period in August, 1897, Aspirin, one of the most widely used and beneficial drugs, and Heroin, one of the most harmful and illegal substances.

Interestingly, Hoffmann developed Aspirin to relieve his father's rheumatism pains and even tested it on him.

Born on 21st January, 1868, in Ludwigsburg, Germany, Hoffman studied Pharmacy and Chemistry at the University of Munich from where he graduated in 1893 with a doctoral degree. In 1894, he began working as a chemist in the research department of Friedrich Bayer & Co. in Elberfeld, Germany, after a recommendation by one of his professors, Adolf von Baeyer.

The professor was a Nobel laureate in Chemistry in 1905 for his work in synthesising dyes.

Felix studied historical records including works by Hippocrates, a Greek physician and researches on pain treatment by Herman Kolbe, Charles Gerhardt, a French chemist and Carl J. Kraut, a German chemist. A compound known as salicin found in willow plants has the power to relieve pain. On 10th August 1897, he synthesised pure acetylsalicylic acid or ASA by combining salicylic acid with acetic acid. The substance had the ability to relieve fever, pain and inflammation, all without upsetting the patient's stomach. He tested it on his father for the safety and effectiveness who had great relief.

Then Hoffman handed over his ASA to the Bayer's Pharmaceutical Laboratory. Heinrich Dreser, was the head of Bayer's laboratory. He rejected it claiming it was not good for the heart. Arthur Eichengrun, Hoffman's supervisor did not accept Dresser's decision. He made further investigations and lobbied for its use. Eichengrun was very rich and influential. He was a great chemist with a number of patents to his credit. Dreser then tested the substance on himself, then on a series of animal experiments and then on people and finally accepted it.

Soon realising its potential, Bayer quickly began a worldwide marketing campaign. Bayer trademarked the name 'Aspirin' in 1899 using 'A' for acetyl chloride, 'spir' for spiraea ulmaria, the Latin name for the plant from which salicylic acid came from, and 'in' as a popular suffix for medicines. Germany refused to award a patent for the development of ASA, but United States granted a patent to Hoffman and the Bayer Company.

In 1900, Bayer Company supplied the drug in water-soluble tablets, first ever of the variety. By 1915, prescriptions for it were not necessary. Hoffman was promoted to the post of Director of Pharmaceutical Marketing. By the time he retired in 1928, Aspirin became one of the most popular over-the-counter drug worldwide.

Hoffman had a penchant for discovery and in the next two weeks of discovering Aspirin, he developed another potent drug, Heroin. With a view to develop a cough remedy, Hoffmann acetylated morphine hoping to produce codeine; he ended up with Heroin. It was extensively sold as cough remedy, to relieve the pain of childbirth and injuries. Bayer produced a ton a year selling it as tablets, cough lozenges, pastilles, etc. By 1913, as negative reports were mounting on Heroin, Bayer stopped its production. The drug is now banned all over the world.

The father of Aspirin and hero of Heroin chose to live away from all publicity. He lived in Switzerland far from the public eye. Felix Hoffmann was never married and had no children. He died in Switzerland on 8th February, 1946.

The workers at Bayer's were used as guinea-pigs those days and they felt heroic after taking this drug, Diacetylmorphine or heroin. Hence it was named as heroin. Curiously, then aspirin required a doctor's prescription but not heroin! And Aspirin was declared not good for heart!

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HOWARD FLOREY
(1898 - 1968 A.D.)

PRODUCTION OF PENICILLIN

What if Albert Alexander scratches himself while shaving?

A small cut on the chin!

What if it was in the ravaging times of World War II in 1941!

We all had it some time or the other, but this cut made history.

Alexander did not bother about the cut at all and after some days it got infected with Septicemia. The policeman was hospitalised with a swollen face, and a temperature of 105^{0} F. Hospital treated him with drugs available those days but without success. When the patient had just a few hours to survive, Florey and Chain butted in with their penicillin. He was their first trial on a human for penicillin.

Good news - after five days, his condition reversed and the patient recovered.

Bad news - enough penicillin was not available with them, the doctors had to resort to the next best thing, extract from the patient's urine.

After all the penicillin available for the experiments was used up, his condition relapsed and the policeman died. It was a classic case of 'the treatment was a success, but the patient died!' However, it was a triumphant demonstration of penicillin on human beings.

The doctor was Howard Walter Florey who shared the Nobel Prize for Physiology or Medicine in 1945 with Ernst Boris Chain and Sir Alexander Fleming for his role in the extraction of penicillin.

Howard Florey was born on 24th September, 1898 in Adelaide, South Australia. His early education was at St Peter's College, Adelaide. He took up Medicine at the University of Adelaide from 1917 to 1921 after an inspiration and persuasion by his high school chemistry teacher.

With a Rhodes scholarship in hand, he went to Oxford University at the end of 1921 and received the degrees of B.Sc and M. A. He married Ethel Reed, fellow medical student in 1926. In the same year he was elected as a fellow at Gonville and Caius College, Cambridge and a year later he had his Ph.D from Cambridge. After a stint in the United States and at the University of Cambridge, he was appointed to the Joseph Hunter Chair of Pathology at the University of Sheffield in 1931. By 1935, he returned to Oxford as a Professor of Pathology and Fellow of Lincoln College.

It is well known that Alexander Fleming discovered the first antibiotic in 1928 on a leftover bread mould and called it penicillin. Serendipitous it was, but he did not further it as he moved on to other areas of research. Howard Florey and his dedicated team at Oxford started where Alexander Fleming left. The team of scientists at Oxford University started purifying penicillin, making clinical trials and mass production.

On 25th May 1940, they gave doses of purified penicillin to eight infected mice and left another eight without any medicine. By the next day, the treated mice had recovered and the untreated mice were dead. Lives of eight mice may be insignificant, but his trials were seen as a miracle and one of the most important clinical trials. After this successful trial, Florey traveled to North Africa to test the effects of penicillin on wounded soldiers.

He advised his team:

"If you do the experiment you may not be certain to get an answer. But if you don't do it, you can be certain not to get one."

His team also included Ethel Reed, his wife and Ernst Boris Chain with whom he shared the Nobel Prize.

At first, penicillin was made using old dairy equipment and hospital bedpans. Mass production required co-operation from the large drug companies, but those in Britain were not ready then because of the war. Florey decided to go to United States. He took upon a dangerous flight along with Norman Heatley in a blacked-out plane across the Atlantic, "I would work with the devil himself...," he once said, "... if he were good enough."

Experiments at the Department of Agriculture laboratory started yielding at higher rates and by late 1943, mass production of the drug had commenced. By the end of World War II, the drug was just available to treat Allied troops. Thanks to Florey and his team, it probably influenced the outcome of the war.

He did not make tall claims of his researches, describing them in an interview in 1967 as a "terrible amount of luck that involved many others". He said:

"All we did was to do some experiments and have the luck to hit on a substance with astonishing properties."

He was awarded the Nobel Prize in 1945 with Fleming and Chain for his role in discovery and development of penicillin. He was knighted in 1944. He was the first Australian to be the President of the Royal Society in 1960. He was made Baron Florey of Adelaide in 1965 and was the Chancellor of the Australian National University in 1965.

Undoubtedly, it is because of his accomplishments that modern life is longer and comfortable. He said in 1967:

"I'm now accused of being partly responsible for the population explosion, one of the most devastating things that the world has got to face for the rest of this century."

But his next line of research was on contraception and he was a vigorous promoter for population control.

Ethel, his first wife died in 1966. Howard remarried in 1967 to Margaret Jennings, an important member of the penicillin team, just a year before his death. He died of a heart attack on 21st February, 1968.

A distant cousin of Alexander Fleming was dying of bacterial meningitis. The discoverer of penicillin had tried for a week to save his friend's life with Sulphur drugs, but without success. He became panicky and wondered whether he could ever save his friend. He then telephoned Florey on a Sunday morning in Oxford, fervently requesting him for some penicillin. Florey came down to London and handed his whole supply of penicillin over to Fleming and gave instructions how to use the doses, how to inject it and what to do. Fleming went back to St Mary's, treated his friend and saved his life.

Nevertheless the hospital called the press in, to announce that they had this wonderful new drug. And Fleming was there, ready in his white coat for his photograph to be taken. When the press reached Oxford to get the other end of the story, humble as he was, Florey refused to see them.

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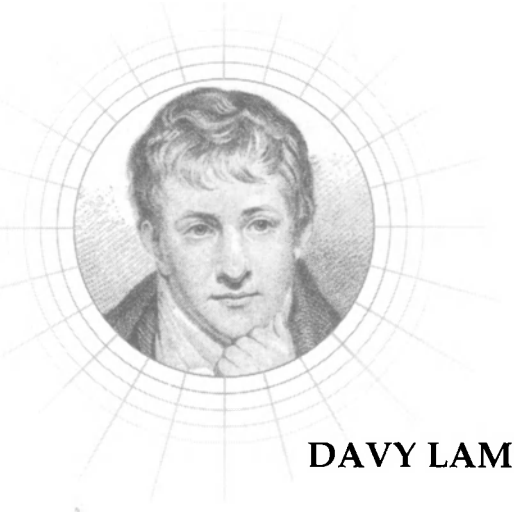

HUMPHREY DAVY

(1778 - 1829)

DAVY LAMP

He was a Fellow of the Royal Society and was their President from 1820 to 1827. He developed the Royal Society into a veritable authority in advanced scientific research. He discovered a large number of chemicals. He was first to invent electric light. His demonstration lectures were largely attended by the high and mighty of the Victorian Era. Ladies flocked to his lectures to see the most important piece of display, the scientist himself.

Humphrey Davy was easily the most handsome scientist.

He was born in Penzance, Cornwall, United Kingdom on 17th December 1778. He was one of those brilliant scientists who were self-taught in a wide range of subjects like Theology and Philosophy and of course Chemistry and other sciences. He learnt seven languages.

One of his earliest experiments was on the physiological effects of certain gases, off which he was particularly fond of was the laughing gas. He was a hit in the social gathering those days, as he used to revel in encouraging others to laugh themselves off with this gas. In 1799, he wrote a book 'Researches, Chemical and Philosophical' chiefly concerning

nitrous-oxide and its respiration and recommended it as mild anesthetic. He was addicted to the gas and claimed that it had all the good of alcohol and none of alcohol's bad qualities. However he lost his eyesight while experimenting with nitrogen trichloride.

In 1801, he became a Professor at the Royal Institution and Fellow of the Royal Society.

Probably he was the father of corrosion control. He proposed the electrical affinity of substances, where some substances react preferentially with other substances. He isolated potassium, strontium, calcium, and magnesium by his electrochemical reactions. In 1807, he isolated sodium through the electrolysis of caustic soda (NaOH). Next year, he isolated Barium through the electrolysis of molten baryta (BaO). In 1809, he connected a charcoal strip to a battery, making the first electric arc lamp. Berzelius was all praise for Davy's 1806 lecture on some chemical agencies of electricity and called it:

"One of the best memoirs which has ever enriched the theory of chemistry."

He married a wealthy widow, Jane Apreece. In 1812, he was knighted, and in October 1813, he started on a tour to France, Italy and other European countries along with his wife and his greatest discovery, Michael Faraday.

Napoleon awarded him a prize for his experiments with electricity. Davy received the honour even though England and France were at war. He said that 'the Governments might be fighting but not scientists.' He opined:

"Fortunately science, like the Nature to which it belongs, is neither limited by time nor by space. It belongs to the world, and is of no country and no age."

Gay-Lussac requested him there to investigate an unexplained substance isolated by Bernard Courtois. Davy found it to be an element, the present-day iodine. Reaching Florence in Italy, he proved that diamond was, after all, carbon by burning

it with the sun's rays. He visited Rome, Naples and Mount Vesuvius. On 17th June, he met Alessandro Volta in Milan. He travelled to Geneva, Munich, and Venice before returning to England.

His book 'Elements of Agricultural Chemistry in a Course of Lectures' espouses the use of Chemistry in agriculture. Davy is best remembered for the miner's lamp. In 1815, he designed a lamp where the flame is surrounded by a wire mesh to prevent ignition of flammable gases found in mines.

The famous French science fiction writer Jules Verne often spoke of Davy in his novels. Davy was a gifted poet and books written by Davy include - 'Researches, Chemical and Philosophical', 'Elements of Chemical Philosophy', 'The Papers of Sir H. Davy', 'Discourses to the Royal Society', 'Salmonia: Or Days of Fly Fishing', 'Consolations in Travel: Or the Last Days of a Philosopher'.

In spite of all his discoveries, he often said, "The more we know, the more we feel our ignorance; the more we feel how much remains unknown..."

In 1818, he was awarded a baronetcy. His health deteriorated due to the chemical inhalations he had in his experiments and Davy died in Switzerland in 29th May 1829. A lunar crater is named after Sir Humphry Davy.

Once a press reporter asked Humphrey Davy, "What is your greatest invention or discovery?"

Davy replied without hesitation, "Michael Faraday!"

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J.B.S. HALDANE

(1892 - 1964 A.D.)

HALDANE'S PRINCIPLE

He was born and brought up in England and married an English woman. But he left his motherland and landed in India, a country he loved dearly. He provided a major thrust towards biological research in India.

With an accent on Mathematics and Statistics, he made some very important discoveries. He wore dhoti and kurta. When he died, he bequeathed his body to Rangaraya Medical College, Kakinada, Andhra Pradesh.

J.B.S. Haldane was born on 5th November, 1892 in Edinburgh, to Physiologist John Scott and Louisa Kathleen. Haldane was educated at Dragon School, then at Eton and at New College, Oxford, where he graduated in 1911. He learnt several languages. He won the Russell Prize at the age of 16, in mathematics.

He took up war service for four years from January, 1915 to January, 1919. His father taught him fearlessness. His fearless bombing skills earned him the nickname 'Bombo'. In 1922, he studied at Cambridge University under Frederick Gowland Hopkins, the discoverer of vitamins. Haldane had the habit of writing essays on science during his high school and college

days. They were later compiled and published in 1927 titled 'Possible Worlds'.

He had his basic education in Humanities, but made contributions in diverse subjects like Physiology, Genetics, Biochemistry, Mathematics, Cosmology. Haldane was a keen experimenter, willing to take risks to obtain data. He even loved exposing himself to study the reactions. He ended up with crushed vertebrae and perforated eardrums in the process, but discovered a cure for tetanus and convulsions.

He was a Fellow of New College, Oxford for three years from 1919 and then moved to Cambridge as a Reader in Biochemistry at Trinity College. In 1924, Haldane became friendly with Charlotte Burghes, a young reporter for the Daily Express. Haldane could marry her, only after she divorced her husband. However, this clandestine affair almost cost him his job at Cambridge.

He applied his talents in Mathematics to study enzymes and Genetics. He was elected as a Fellow of the Royal Society in 1932 for his studies in Genetics. A year later he joined University College, London, as Professor of Genetics. After four years of stay there, he became the first Weldon Professor of Biometry.

Professor P C. Mahalanobis invited him to India to join the Indian Statistical Institute, Calcutta (now Kolkata), as a Research Professor in 1957. He loved this biologically diverse country with multi-ethnic and multi-cultural races. Naturally he had a field day in India. He even liked to wear the traditional Indian dresses. He left the Institute in 1962 to join the Council of Scientific and Industrial Research, New Delhi. He started his own Genetics and Biometry Laboratory at Bhubaneshwar.

He delivered lectures on science subjects at many places including All India Radio and also encouraged young scientists in their research. He guided a whole generation of young scientists in a systematic study with emphasis on Quantification, Statistical design and Analysis. In 1961, Haldane stated:

"I owe a great deal to this (Indian Statistical) Institute, but what I undoubtedly owe most is the opportunity it has given me of making some very important discoveries, namely, the

discoveries of a number of younger men than myself, who, I think, are in the great tradition of scientific research."

Haldane advised his young scientists:

"If you want to excel in science, try to develop the habit of quantitative thinking. It is your duty to begin thinking statistically about anything that can help your country and the world."

Driving a major emphasis into biology teaching in India, he started a unique degree course in Statistics at the Indian Statistical Institute where the curriculum included Natural and Social Sciences also.

He made extensive use of Mathematics in biological studies and recommended that if someone is faced with a difficulty or a controversy in Science, an ounce of Algebra is worth a ton of verbal argument. In fact, he was the first to use Mathematics in Genetics and developed mathematical theory of population genetics. His greatest contribution was a series of papers on 'A Mathematical Theory of Natural and Artificial Selection'. His Quantitative Approach in Biology can be seen in his essay 'On Being the Right Size', since referred to as Haldane's principle.

Continuing his early habit of writing, he wrote a number of popular science articles like 'The Causes of Evolution,' 'What is life?', 'Science and Ethics' and 'My friend, Mr Leakey' for children.

His anthology contains among others, 'Possible Worlds and Other Essays'(1927), 'Animal Biology' (1929), 'Enzymes' (1930), 'The Causes of Evolution' (1932), 'Science and Human Life' (1933), 'Science and the Supernatural: Correspondence with Arnold Lunn' (1935) and 'Fact and Faith' (1934).

He received the Feltrinelli Prize, and the Kimber Award of the US National Academy of Sciences and Darwin Medal from the Royal Society. In 1956, he was awarded the Huxley Memorial Medal of the Royal Anthropological Institute and received Honorary Doctorate of Science, and Honorary Fellowship at New College.

Haldane once said:

"My own suspicion is that the Universe is not only queerer than we suppose, but queerer than we can suppose."

Even while suffering from cancer, he did not lose his cheer. He wrote one of the finest poems written on a scientific subject – 'Cancer's a Funny Thing'. He succumbed to the disease at the age of 71 at Bhubaneswar on 1st December, 1964.

His last wish was:

"My body has been used for both purposes during my lifetime and after my death, whether I continue to exist or not, I shall have no further use for it, and desire that it shall be used by others. Its refrigeration, if this is possible, should be a first charge on my estate."

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"Cancer's a Funny Thing:
I wish I had the voice of Homer
To sing of rectal carcinoma,
Which kills a lot more chaps, in fact,
Than were bumped off when Troy was sacked..."

JACK KILBY
(1923 - 2005 A.D.)

INTEGRATED CIRCUIT

Transistor was an outstanding invention which revolutionised electronics. But, building complex circuits required a large number of transistors and other passive components. Wiring them individually was a mammoth task and a tyranny of numbers. It was the scenario when Jack Kilby joined the Semiconductor Lab at the Texas Instruments.

In that providential July 1958, he was alone in the deserted laboratory. He was not allowed vacation like his other colleagues because he joined the company only recently. His thoughts were on solving the problem of numbers. Kilby wrote about his experience in a 1976 article titled 'Invention of the IC':

"I also realised that, since all the components could be made of a single material, they could also be made in situ interconnected to form a complete circuit."

The result was exhibited to a handful of workers, executives and the former chairman of Texas Instruments on 12th September, 1958. It was a slice of a centimeter wide germanium, with protruding wires, glued to glass slide. When Kilby pressed the switch, the oscilloscope showed a sine wave. It was the first Integrated Circuit and the world never looked back.

While the first IC had only a few components, present integrated circuits and microprocessors contained millions of them. But did Jack Kilby take all the credit for this? No! He said:

"Well, I don't know that I get credit for their profound effect. It's true that the original idea was mine, but what you see today is the work of probably tens of thousands of the world's best engineers, all concentrating on improving the product, reducing the cost, things of that sort."

He didn't realise then that the integrated circuit would reduce the cost of electronic functions by a million to one.

In the meantime, Robert Noyce also developed an integrated circuit based on silicon. In a historical coincidence, both of them invented the IC without knowing each other and about the same time. In a world torn with jealousy, personal egos and profits, read what Kilby wrote in an autobiography submitted to the Nobel committee:

"I would like to mention another right person at the right time, namely Robert Noyce, a contemporary of mine who worked at Fairchild Semiconductor. While Robert and I followed our own paths, we worked hard together to achieve commercial acceptance for integrated circuits. If he were still living, I have no doubt we would have shared this prize."

Need we add anything else to speak about the greatness of the man who transformed twentieth century?

Nobel Prize was awarded to him in 2000, more than forty years after his breakthrough. He wrote in his autobiography:

"Receiving the Nobel Prize in Physics was a completely unexpected, yet very pleasant surprise. I had to start my pot of coffee very early the morning I received the news that I had been chosen. Whether the research is applied or basic, we all stand upon the shoulders of giants - as Isaac Newton has said. I'm grateful to the innovative thinkers who came before me, and I admire the innovators who have followed."

Rare breed of humility personified! He was not unhappy at his late selection to the Nobel either:

"It's not too late — at least I'm still alive. You have to live long enough to receive the Prize."

Jack St. Clair Kilby was born in Jefferson City, Missouri on 8th November, 1923. He graduated from Great Bend High School, in Great Bend, Kansas. Kilby received his Bachelor of Science degree from the University of Illinois at Urbana-Champaign. In 1947, he received a degree in Electrical Engineering, just an year before Bell Labs announced the invention of the transistor. He worked with an electronics manufacturer in Milwaukee, Wisconsin, that made parts for radios, televisions and hearing aids. While in Milwaukee, he took evening classes at the University of Wisconsin towards a master's degree in Electrical Engineering. He received his masters in 1950.

In 1958, he moved to Dallas, Texas with his wife when he took up a job with Texas Instruments. The historic demonstration of the first microchip was made on 12th September, 1958. It was a phase-shift oscillator, half-an-inch long and narrower than a toothpick. The patent for the first integrated circuit, 'Solid Circuit made of Germanium', was filed on 6th February, 1959.

Patrick E. Haggerty, former TI (Texas Instruments) Chairman, challenged him to design a calculator that could fit in the coat pocket and replace those bulky electro-mechanical desktop models available those days. The result is the hand-held calculator, of which Kilby is a co-inventor. He held about 60 patents including a thermal printer.

In 1970, he took a leave of absence from TI to do some independent work. While on leave, one of the things he worked on was how to apply silicon technology to help generate electrical power from sunlight. From 1978 to 1984, he spent much of his time as a distinguished Professor of Electrical Engineering at Texas A&M University.

He officially retired from TI in 1983. National Medal of Science was awarded to him in 1969 and he was inducted

into the National Inventors Hall of Fame in 1982. He said on the occasion:

"Seeing your name alongside the likes of Henry Ford, Thomas Edison and the Wright Brothers is a very humbling experience."

He received the National Medal of Technology in 1990, the Eta Kappa Nu Vladimir Karapetoff Award in 1999, the Franklin Institute's Stuart Ballantine Medal, the American Society of Mechanical Engineers' Holley Medal, the IEEE's Medal of Honor, the Vladimir Zworykin Award and the Charles Stark Draper Prize by the (NAE) National Academy of Engineering, (along with Robert Noyce in 1989), the Cledo Brunetti Award, and the David Sarnoff Award and Japan's Kyoto Prize in 1993.

Jack Kilby held honorary doctorates from Rochester Institute of Technology (RIT) and Southern Methodist University. Texas Instruments research center was named after him as Kilby Center. Similarly Napier University in Edinburgh named 'The Jack, Kilby Computer Centre' at the Merchiston Campus in his honour. The Kilby Award Foundation was founded in 1990 in his honour. He was a Fellow of the Institute of Electrical and Electronics Engineers (IEEE) and a member of the National Academy of Engineering (NAE).

Kilby died on 20th June, 2005 at the age of 81 in Dallas, Texas, due to cancer.

During World War II, the radios used by the forces were heavy and erratic; not designed for jungle warfare. Kilby wanted to improve the situation and travelled to Calcutta (now Kolkata) for a truckload of black-market radio parts. Soon he succeeded in building smaller, more reliable radios for the troops. His invention of integrated circuit stems from this attitude. If something does not meet your requirements, rebuild.

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JAYANT VISHNU NARLIKAR

(1938 A.D....)

ASTROPHYSICIST

He was only 26, when his new theory of gravitation presented in collaboration with Fred Hoyle, was hailed as momentous as Einstein's Theory of Relativity. International scientific community considered him as India's Einstein. When the President of India conferred on him Padma Bhushan in 1965, he was hardly 26.

That was Jayant Vishnu Narlikar, born on 19th July, 1938 in Kolhapur, Maharashtra. His father Vishnu Vasudeva Narlikar was the Head of the Mathematics Department at Benaras Hindu University (BHU) and his mother Sumati Narlikar was a Sanskrit scholar. He lived in an atmosphere of mathematicians all around him. One of his uncles would write a mathematics problem on a blackboard every morning and it would be rubbed off only after young Jayant had solved it. In 1957, Jayant topped B.Sc examination of Benaras Hindu University. He joined Cambridge University as a Berry Ramsey Fellow, where he was awarded a Wrangler and Tyson Medal. He also received the Smith's Prize in 1962 and the Adams Prize in 1967. He got his Ph.D in 1963 and D. Sc. in 1976. He was a Fellow of King's College between 1963 and 1972 and was also a founder staff member of the Institute of

Theoretical Astronomy during 1966-72. He collaborated with Fred Hoyle, specialising in Cosmology and Astrophysics.

In 1966, Narlikar married Mangala Rajwade, a Ph.D in mathematics. They have three daughters. While he was in UK, he frequently contributed articles on astronomy to magazines like 'Discovery' and 'New Scientist', which were well appreciated by the readers. Soon he was in popular demand as a public speaker.

After returning to India, Narlikar joined the Tata Institute of Fundamental Research in 1972 and brought the Theoretical Astrophysics Group to world-wide repute. In 1988, the University Grants Commission invited him as Founder Director of Inter-University Centre for Astronomy and Astrophysics (IUCAA), being newly set up then. Under his guidance, IUCAA became a center of international standing in teaching and research in Astronomy and Astrophysics. After retirement in 2003, he is now Emeritus Professor there. His work has been on the frontiers of gravity and Mach's Principle, Quantum Cosmology.

Professor J.V. Narlikar is a prolific writer in English, Marathi and Hindi. Some of his books were translated in other languages. He has been an excellent science communicator through articles, science fiction stories, novels, books, and radio/TV programmes. He authored scientific fiction novels like 'The Return of Vaman', 'The Adventure' in English and 'Yakshachi Dengi', 'Preshit', 'Virus', 'Vaman Parat Na Ala', 'Abhayaranya', 'Aakashashi Jadale Nate' in Marathi.

Some of his popular books in English are 'The Lighter Side of Gravity' and 'Seven Wonders of the Cosmos'. His technical books include 'The Structure of the Universe' (1977), 'The Lighter Side of Gravity' (1982), 'Highlights in Gravitation and Cosmology' (1989), 'Philosophy of Science: Perspectives from Natural and Social Sciences' (1992), 'From Black Clouds to Black Holes', (1996), 'Quasars and Active Galactic Nuclei : An Introduction' (1999), 'An Introduction to Cosmology' (2002), 'Scientific Edge: The

Indian Scientist from Vedic to Modern Times' (2003), and 'Current Issues in Cosmology' (2006).

Children's Film Society of India had the privilege of making his science fiction story Dhoomaketu (the Comet) in a 2-hour film. A TV serial by him called Brahmand (The Universe) in 17 parts was shown across in India. This serial unfolds exciting discoveries in astronomy in a simple language laced with stories and anecdotes.

He was a popular public speaker all over India. He developed innovative techniques for popularisation of science. One such method is science through postcard. Whenever any school going child asked him for a photograph, he would prevail upon him to write to him a postcard with some scientific question. His replies generated a momentum of postal questions and answers.

He received numerous awards; a few of them are Bhatnagar award, M.P. Birla award, Indira Gandhi Prize by the Indian National Science Academy in 1990, and the Kalinga Prize by UNESCO in 1996. In 2004, he was conferred Padma Vibhushan - India's second highest civilian honour.

He was President of the Cosmology Commission of the International Astronomical Union from 1994 to 1997. He is Fellow of the Third World Academy of Sciences and three other national science academies.

Narlikar is famous amongst Indians who saw him on TV giving a prologue to each episode of Carl Sagan's 'Cosmos: A Personal Voyage', in the late 1980s.

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JOHN BARDEEN

(1908 - 1991 A.D.)

TRANSISTOR

One evening, in the winter of 1947, a scientist returned home from his laboratory at the Bell Labs. With a glint of satisfaction in his eyes, he told his wife, Jane, "I think we discovered something today." She was busy making dinner and didn't bother about it. That discovery of something changed the facade of the twentieth century. World is not the same again. Without this invention of the transistor, the microelectronics, personal computers and super computers, the revolution in Electronics and Communication would still be the stuff from science fiction stories.

Then, on the morning of the 1st November, 1956, he was scrambling eggs for the breakfast. The radio announced that the Nobel Prize in physics had been awarded to him along with two of his colleagues for an invention made in 1947. He just dropped the frying pan, ran and broke the news to his wife Jane. John Bardeen, Walter H. Brattain, and William Shockley were awarded Nobel Prize in Physics in 1956, for their investigations on semiconductors and the discovery of the transistor effect.

The Nobel ceremony took place in Sweden on the evening of 10th December. John Bardeen did not want to disturb the

studies of his two sons at Harvard. So he brought only his third son to the Nobel ceremony. King Gustav chided Bardeen for leaving his family behind on such an important occasion. He assured the King that the next time he would bring all his children, as if he would bring them for the next day market.

But, he kept his word and did bring all his children to the next Nobel ceremony. John Bardeen is the only person in history to receive two Nobel Prizes in physics. In 1972, Bardeen was awarded Nobel again along with L.N. Cooper and J.R. Schrieffer for successful explanation of superconductivity. But a true genius, he simply said:

"My earlier award was also based on a close collaborative effort. But I am sure it will be Superconductivity that will change the face of the twenty-first century."

John Bardeen was born in Madison, Wisconsin on 23rd May, 1908. He was the second son of Dr. Charles Russell Bardeen, Dean of the University of Wisconsin Medical School, and Althea Harmer Bardeen, a well-educated young lady.

He graduated with a B.S. and did his masters in Electrical Engineering from the University of Wisconsin. He had a brief stint at the Gulf Oil Company as a geophysicist. But his heart was in research. He went to Princeton, the hub of activity those days and did his Ph.D in 1936 in Solid-State Physics, under Nobel Laureate Physicist Eugene Wigner. Harvard hired him as a Junior Fellow with a substantial salary. He met his sweetheart Jane Maxwell, a biologist and teacher. He married her in 1938. After Harvard, Bardeen moved to the University of Minnesota. In the World War II, he worked with the Naval Ordinance Labs, where his services were recognised by the Meritorious Civilian Service Award.

Soon after the war, Bell Labs formed a new research group to device a better amplifier without the use of vacuum tubes. Bardeen joined Shockley and Brattain. John Bardeen and William

Shockley were school-mates in Massachusetts. It was a great team. Shockley was a visionary. Bardeen was a thinker and Brattain was the tinkerer. Soon after inventing the transistor, they drifted apart due to clash of egos and personal flourish. Bardeen once wrote to Mervin Kelly, the President of Bell Labs:

"My difficulties stem from the invention of the transistor. Before that there was an excellent research atmosphere here."

The rift had begun. The University of Illinois enticed him with better salary and better research facilities. He worked there from 1951 to 1975. John Bardeen started working on superconductivity, which always fascinated him.

In 1957, Bardeen developed the first theory on how metals loose all their electrical resistance and conduct electricity efficiently. This Superconductivity Theory is known as the BCS Theory (for Bardeen, Cooper, and Schrieffer). Cooper and Schrieffer were his students. In 1972, BCS were awarded a Nobel Prize. Bardeen always felt:

"The combined results of several people working together is often much more effective than could be that of an individual scientist working alone."

To keep up his word given to King Gustav, he did take all his children to the next Nobel ceremony. He believed:

"Any particular advance has been preceded by the contributions of those from many lands who have set firm foundations for further developments."

He gave most of his Nobel Prize money to fund the Fritz London Memorial Lectures at Duke University. He believed:

"Science is a field which grows continuously with ever expanding frontiers. Further, it is truly international in scope."

He was a fellow of American Physical Society, member of the National Academy of Sciences in 1954 and the United States President's Science Advisory Committee. He received the Stuart Ballentine Medal of the Franklin Institute in 1952, the John Scott

Medal of the City of Philadelphia in 1955, (both awarded jointly with Dr. W.H. Brattain), the Buckley Prize of the American Physical Society in 1955 and the Fritz London Award. He received honorary D.Sc. from Union College and from the University of Wisconsin.

He lived in Champaign-Urbana. He was a rare person who changed the life of every human being. Bardeen died of cardiac arrest in Boston, Massachusetts on 30th January, 1991 at the age of eighty-two.

Interestingly, Bardeen borrowed a white vest and white tie for his formal suit for the Nobel ceremony from Brattain since Bardeen's vest and tie got spoiled at the laundry. Another side light was that he lost the photographic plates required for the Nobel presentation in a taxi. Efforts by the Swedish government to retrieve them were not successful.

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He was a keen golfer. When someone asked him whether he was proud of his two Nobel prizes or his hole-in-one he scored in golf, he said, "I guess two Nobel Prizes are better than one hole-in-one."

JONAS SALK
(1914 - 1995 A.D.)

POLIO VACCINE

He did not seek wealth or fame through his innovations. "Who owns my polio vaccine? The people! Could you patent the Sun?" was his famous quote.

But his invention saved millions of children across the globe from the dreaded disease that crippled them for lifelong and relieved thousands of parents from their lifetime of worry. It is a surprise that in the beginning of his career, he was not interested in science at all and he wanted to become a lawyer. His mother persuaded him from a pre-law student to a pre-med student. He later accepted:

"As a child I was not interested in science. I was merely interested in things human, the human side of Nature."

His opponents deranged him by saying, "Salk was strictly a kitchen chemist. He never had an original idea in his life."

He even tested his vaccine on himself and his wife in 1954. When the results were declared on 12th April, 1955 after an American nationwide massive double-blind testing of his drug, he did not give credit to anybody, including himself. But many parents heaved a sigh of relief and it was the beginning of eradication of polio from the globe.

The man behind this medical revolution of eradication of polio was Jonas Edward Salk, son of Orthodox Polish-Jewish immigrants, Daniel B. Salk and Doran. Jonas was born on 28th October, 1914 in New York City. He was the only child to go to the college in the family. He believed:

"Good parents give their children roots and wings. Roots to know where home is, wings to fly away and exercise what's been taught to them."

He received a B.Sc. from the City College of New York, and a Medical degree from the College of Medicine at New York University in June. While still at the medical college, he was invited for research on influenza. He had stints at the Mount Sinai School of Medicine in New York City and at the University of Michigan in Ann Arbor. His strong belief was that nothing happened quite by chance. It's a question of accretion of information and experience for which he worked relentlessly for next few years.

He married Donna Lindsay on 9th June, 1939, whom he met while still in college.

The general belief those days was that immunity can be acquired only after a mild infection by live virus in the lines of Louis Pasteur. But Salk followed his faith. He worked on his intuition:

"Intuition will tell the thinking mind where to look next. It is always with excitement that I wake up in the morning wondering what my intuition will toss up to me, like gifts from the sea. I work with it and rely on it. It's my partner."

He looked differently and killed the poliomyelitis virus using formaldehyde, but kept the virus intact enough to trigger the necessary immune response by the body. He was successful and caught the eyes of Basil O'Connor, the head of the National Foundation for Infantile Paralysis. Salk became the Head of the Virus Research Lab at the University of Pittsburgh in 1947.

A large medical experiment was launched in the US, vaccinating more than a million kids in the most susceptible age group of six to nine. It was a double blind exercise as some kids were given the vaccine, some others with a placebo. The children or the researchers would not know who got what.

His nationwide trials were victorious and by 1956, he became famous all over the world as more and more countries were successfully immunising their children with his vaccine against polio. In 1963, Salk founded the Jonas Salk Institute for Biological Studies, an innovative center for medical and scientific research.

Albert Sabin developed an alternative vaccine with live-virus oral vaccine in parallel and it was a clash of titans for some time. To this Salk said:

"I have had dreams, and I've had nightmares. I overcame the nightmares because of my dreams."

Salk was awarded 'The Lasker Award in 1956' and 'The Bruce Memorial Award' in 1958. Salk was elected to the Polio Hall of Fame, at Warm Springs, Georgia on 2nd January, 1958.

In 1965, he established the Salk Institute for Biological Studies in La Jolla, California, for studying Molecular Biology and Genetics and was its director till his retirement in 1985. Jacob Bronowski and Francis Crick graced the Institute as the earliest faculty.

In 1968, he divorced his first wife with whom he had three children. He married Françoise Gilot, the former mistress of Pablo Picasso in 1970. He published two books named 'Man Unfolding' in 1972 and 'The Survival of the Wisest' in 1973.

Nobel Prize eluded him, but he never hankered after awards or prizes. But the Jawaharlal Nehru Award in 1975, and Congressional Gold Medal and Presidential Medal of Freedom in 1977 followed him. Jonas Salk continued to publish books. His book 'World Population and Human Values: A New Reality' was published in 1981 and 'Anatomy of Reality' was published in 1983.

Age had not withered his dreams as he said:

"Hope lies in dreams, in imagination and in the courage of those who dare to make dreams into reality."

By 1995, he concentrated his researches on AIDS at 'The Immune Response Corporation' which he co-founded and patented a vaccine p4 as 'Remune'.

Jonas Salk died on 23rd June, 1995, when he was 80 years old at La Jolla due to heart failure.

Salk was inducted into the California Hall of Fame located at The California Museum for History, Women and the Arts in Sacramento on 5th December, 2007.

Salk was once asked how he managed to invent the polio vaccine.

"I pictured myself as a virus or a cancer cell," he replied, "and tried to sense what it would be like."

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LINUS PAULING

(1901 - 1994 A.D.)

CHEMICAL BOND

He is the only person to win two Nobel Prizes which were not shared by anyone else. But he did not qualify for his High School diploma. Ironically the school relented and awarded him the diploma 45 years later after he had won two Nobel Prizes.

Isaac Asimov called him 'a gentleman in highest sense of the word.'

American Senate Internal Security Subcommittee questioned him for his 'Soviet Communism'.

Life magazine dubbed his 1962 Nobel Prize as 'A Weird Insult from Norway'.

Linus Torvalds, the creator of Linux Operating System, was named after Pauling by his parents.

That brings us to Linus Carl Pauling, an American quantum chemist and biochemist, a crystallographer, molecular biologist, and medical researcher, a physicist and above all, one great scientist all rolled into one.

Pauling was born in Portland, Oregon, USA on 28th February 1901. His parents were Herman Henry William, a pharmacist and Lucy Isabelle. He was a voracious reader as a child. His father

had to write a letter to a local paper, 'The Oregonian' inviting donation of additional books to satiate his boy's hunger.

His father did not live long to share his son's glory. Linus was forced to take up odd jobs not only to support the family of his ailing mother and sisters but also to finance his own education. In 1914, Pauling completed his schooling from the Sunnyside Grammar School and Portland's Washington High School. Pauling built a small laboratory in the basement of his house. Chemicals came from a small laboratory at the abandoned Oregon Iron and Steel Company, nearby.

He joined Oregon Agricultural College. To pay for his studies, he worked in a machine shop as a paving inspector during the day and at night as a milk vendor. It was a very hard job, working eight hours every night with a horse pulling the milk wagon and delivering milk to about 500 customers.

But then he got an extraordinary offer from Oregon Agricultural College to teach Quantitative Analysis in Chemistry, while he was still a student there. In 1922, Pauling graduated from OAC with a degree in Chemical Engineering. He received his Ph.D in Physical Chemistry and Mathematical Physics in 1925 from California Institute of Technology (Caltech), where he published seven papers on the crystal structure of minerals. Pauling married Ava Helen Miller on 17th June, 1923. They had a daughter and three sons.

During 1926-27 he studied in Europe on a Guggenheim Fellowship under German physicist Arnold Sommerfeld in Munich, Danish physicist Niels Bohr in Copenhagen and under Austrian physicist Erwin Schrodinger in Zurich. He returned to Caltech as Assistant Professor of Theoretical Chemistry and Mathematical Physics, where he later became a Professor. He studied molecular structure of chemical substances with an electron diffraction instrument which he built. He published about fifty papers in those five years, and created five rules which are now known as Pauling's Rules.

In 1931, Pauling received the Langmuir Prize by the American Chemical Society. He introduced the concept of Electronegativity in 1932. Linus was well versed in Quantum Mechanics and applied methods like X-ray diffraction, electron diffraction and magnetic effects. He said:

"I have decided to attack the problem of the structure of nuclei."

He demonstrated the changes in haemoglobin molecule structure and the cause of sickle-cell anaemia as molecular disorder. His researches on amino-acids and their structure influenced F.H.C. Crick and J.D. Watson in their research on DNA.

He remarked:

"I have always liked working in some scientific direction that nobody else is working in."

In 1939 he published his monumental book on the chemical bond in 'The Nature of the Chemical Bond and the Structure of Molecules and Crystals.' This classic in Chemistry is widely read, widely translated and extensively cited book. His next book 'How to Live Longer and Feel Better' is another powerful and popular book published in 1986.

He was a profound peace activist. His book 'No More War' (1958) was an instant best-seller. During World War II, he rejected an offer from Robert Oppenheimer (his friend from Caltech days) to be the head of the Chemistry division of the Manhattan Project. In 1946, he joined hands with the Emergency Committee of Atomic Scientists, chaired by Albert Einstein and warned the public and the governments of the dangers of nuclear weapons. He signed Russell-Einstein Manifesto in 1955 along with other leading scientists. He presented another petition signed by 11,000 scientists to the United Nations for a ban on testing of nuclear-weapons. It was 'A Lifelong Quest for Peace' just as he suggested in the title of his another book.

In 1952, the US State Department impounded his passport as a tribute to his peace activity, but was just released in time to

accept his Nobel Prize. Nobel committee awarded him the Nobel Prize in Chemistry in 1954 for his work on the nature of the Chemical Bond.

Pauling continued his researches in Chemistry and Physics in his 'Linus Pauling Institute of Science and Medicine' in Menlo Park, California, till 1973 and later at Corvallis, Oregon. Concerned about air pollution, he started working on a cheap and practical electric car.

The awards he received were numerous, only to quote some more: Davy Medal from Royal Society (1947), Pasteur Medal from Biochemical Society of France (1952), Avogadro Medal from Italian Academy (1956), Pierre Fermat Medal in Mathematics (1957), Medal from Academy of the Rumanian People's Republic (1965), United States National Medal of Science (1972), International Lenin Peace Prize from USSR (1972), Priestley Medal from American Chemical Society (1984), Award in Chemical Education from American Chemical Society (1987).

Isaac Asimov called Pauling a first-class genius and the greatest chemist of the 20th century.

Pauling died of prostate cancer on 19th August, 1994.

Staunch proponent of Vitamin C in curing almost all diseases, he used to take 10 grams of Vitamin C every day.

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LOUIS JEAN PASTEUR
(1822 - 1895 A.D.)

PASTEURISATION

In 1940, Germans invaded Paris and reached the Pasteur Institute. They pounced on the caretaker, Joseph Meister and ordered him to open the famous crypt for inspection. Joseph refused to do it. Germans pointed their guns. In a moment Meister killed himself rather than open his master's crypt. What was so great about the crypt and what was so great about his master?

Some fifty-five year earlier, on 6th July, 1885, a rabid dog had badly bit Joseph Meister. This 9-year-old boy was brought to a scientist. The scientist had spectacular success on rabbits and other animals in the treatment of rabies. But the scientist was in a dilemma as he was not a licensed physician. If the boy was left untreated, he was sure to die from rabies. He decided to face the consequences rather than see the boy dying. Joseph was given the course of 14 injections and he survived. Rest is history and man's triumph over a number of diseases.

Louis Jean Pasteur transformed life on Earth and revolutionised Chemistry, Agriculture, Industry, Medicine, Surgery and Hygiene. He laid the foundations of three distinct sciences - Immunology, Microbiology and Stereochemistry.

When Pasteur Institute was built, Joseph Meister became a caretaker there. After Pasteur's death on 28th September, 1895, his remains were initially cremated in the Cathedral of Notre Dame but later transferred to a permanent crypt in the Pasteur Institute. Joseph Meister had refused to yield to Nazi threats there, in 1940, and paid with his life, a tribute to his master.

Pasteur was born on 27th December, 1822 in Ole in France. His father Jean Pasteur was an uneducated tanner. But in the words of Pasteur:

"He was my first teacher and it was he who inspired in me the love for work, direction for my work and instilled in me the love for my country."

In his childhood, he used to make portraits of his family members, classmates and neighbours. Brilliant student that he was, his headmaster encouraged him to join the Ecole Normale Superieure. With his doctoral thesis on Crystallography, he became Professor of Chemistry at Strasbourg University. He married Marie Laurent, daughter of the University's rector on 29th May, 1849 after a brief courtship. In 1854, he was appointed as the Dean of the new College of Science in Lille. In 1856, he was named as the Director of scientific studies of the Ecole Normale Superieure. It was at Normale Ecole that Pasteur carried out most of his fruitful investigations. He was an ardent Catholic.

He had the ability to conduct his researches under strictly controlled conditions and infer correct conclusions from the experimental results. He always said:

"The greatest mischief of the mind is to believe certain things, as by believing we would want them to be so."

In his early days, he solved the problem of polarisation of light passing through tartaric acid. Natural tartaric acid exhibited polarisation of light whereas the artificial tartaric acid did not show such effect. In 1856, a distiller by name M. Bigot requested

his help in the manufacture of alcohol by fermentation, where the theme process yielded lactic acid instead of alcohol. After a careful study, he suggested heating the wine slightly to kill the contaminated organism after the fermentation was complete, a process now world famous as pasteurisation. He advised them to close the containers to avoid ingress of bacteria through the dust and air. His researches revolutionised not only the vinegar, the wine and the beer industry but also the bread, milk and cheese industries. He is thus the father of 'Germ Theory' and 'Bacteriology'. Pasteur also discovered anaerobiosis, where some micro-organisms thrive without air or oxygen.

In 1865, silk-worm farmers looked up at Pasteur to save the dwindling silk industry in southern France because of diseases to silk-worm. His methods of selection of good worms, rejection of sick worms and the use of microscope nursed the sick silk industry back to good health. But Pasteur himself suffered a stroke and partial paralysis around that time.

Edward Jenner had discovered vaccination, using cowpox to immunise from the deadly smallpox in 1796. Pasteur developed a vaccine in 1870s against anthrax, a particularly deadly, highly communicable disease of domestic animals. Pasteur gave these artificially weakened diseases the generic name of vaccines, to honour Jenner's discovery. The results were astounding and savings to his country were enormous and immediate.

Pasteur said:

"Science...it is my life...it has brought me a deepness of pleasure that I have always known yet never realised."

He received the Leeuwenhoek medal, microbiology's highest honour, in 1895. He was Grande Croix of the Legion of Honor.

He was a great patriot and a still greater humanist who did not patent his discoveries. His philosophy was:

"Science is the main passion of my life. My whole life is devoted to it. I feel that I am harbouring two deep impressions: the first is that science does not have any nation; the second, which seems to be independent of the first, but is still a direct consequence of it, is that science is the highest personification of the nation, as amongst all the peoples, those who march ahead with their thought and intelligence always lead."

Both Pasteur Institute and Universite Louis Pasteur were named after him. At the inauguration of the Pasteur Institute on 14th November, 1888, in the presence of French President, Sadi Carnot, Pasteur became so emotional that he could not read his speech and his son helped him over. He died on 28th September 1895, near Paris, due to the complications arising from the days of his silk-worm investigations.

Louis Pasteur, had an obsessive fear of dirt and infection. He refused to shake hands, carefully wiped his plates before dining, and, on more than one occasion, astonished friends at dinner parties by producing a portable microscope to ensure that the food they were serving was fit for human consumption.

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M S SWAMINATHAN

(1925 A.D....)

GREEN REVOLUTION

When Dr. Norman Borlaug received the Nobel Peace Prize in 1970, he said:

"The green revolution has been a team effort. However, to you, Dr. Swaminathan, a great deal of the credit must go for first recognising the potential value of the Mexican dwarfs. Had this not occurred, it is quite possible that there would not have been a green revolution in Asia."

Presenting the First World Food Prize to Dr. Swaminathan in October 1987, Mr. Javier Perez de Cuellar, the then-Secretary General of the United Nations, wrote:

"Dr. Swaminathan is a living legend. His contributions to Agricultural Science have made an indelible mark on food production in India and elsewhere in the developing world. By any standards, he will go into the annals of history as a world scientist of rare distinction."

He was described as the Father of Economic Ecology by the United Nations Environment Programme. TIME Magazine in 1999 nominated him in the list of the 20 most influential Asian people of the 20th century. The other two were Mahatma Gandhi and Rabindranath Tagore.

People reaping the harvests in the modern technological miracles often fail to recognise the impact of the researches and the results made by agricultural scientists. People in their present sixties and beyond would recall how the country waited for the American PL480 ship to arrive with wheat load and how Prime Minister Lal Bahadur Shastri used to exhort citizens to miss a meal one day in a week so that the food thus saved could be fed to other hungry mouths.

India was written off as hopeless. Biologist Paul R. Ehrlich wrote in his 1968 bestseller, 'The Population Bomb':

"I have yet to meet anyone who thinks India will be self-sufficient in food by 1971...India couldn't possibly feed two hundred million more people by 1980."

M S Swaminathan entered such a scene and our history changed from that time.

Monkombu Sambasivan Swaminathan was born on 7th August, 1925, in Kumbakonam, Tamilnadu. He was 11 years old when he unexpectedly lost his father who was a surgeon. He had his early education at the Native High School and the Little Flower Catholic High School in Kumbakonam. He received his Bachelor's degree (B.Sc.) in Zoology at Maharajas College in Trivandrum and another in Agricultural Science from Coimbatore Agricultural College.

He acquired his post-graduate degree with high distinction in Cytogenetics in 1949 at the Indian Agricultural Research Institute (IARI) in New Delhi. He began research on potato genetics at the Wageningen Agricultural University, Institute of Genetics in the Netherlands on a UNESCO Fellowship. In 1950, he was at the Plant Breeding Institute of the University of Cambridge School of Agriculture, where he received his Ph.D doctorate in 1952.

He spurned an offer for professorship and returned to India in early 1954. On asking about the reason for his returning back to India, he said:

"I asked myself, why did I study Genetics? It was to produce enough food in India. So I came back."

From now on, it was a saga of research, innovations, developments and above all, field trials, results, improvements, implementation and success in feeding hungry mouths, while teaching of Cytogenetics, Radiation Genetics, and Mutation Breeding was going hand in hand.

Swaminathan lobbied with the then-Prime Minister Lal Bahadur Shastri, to import 18,000 tons of the Mexican seed when the country was reeling under financial difficulties. Swaminathan recalls:

"He probably thought nothing could be worse. Famine was imminent. There was a willingness to take risks."

With help from the Rockefeller Foundation, Swaminathan cross-bred Mexican wheat seed with Japanese and meeting the colour, taste, quality, quantity and harsh conditions of Indian soil and climate.

He established the National Bureau of Plant, Animal, and Fish Genetic Resources of India and the International Plant Genetic Resources Institute. Swaminathan is a Fellow of the Royal Society of London and National Academies of Sciences in U. S., Russia, China, and Italy. He holds about 50 honorary doctorate degrees from Universities all over the world and over 68 students received their Ph.Ds under his guidance.

A few of the important positions he held are — Director-General, Indian Council of Agricultural Research (ICAR) during 1970–80; Principal Secretary in the Ministry of Agriculture, Government of India; Independent Chairman, FAO Council, Rome (1981- 85); President of the International Congress of Genetics (1983); the Director General, IRRI (1982–88), President, World Wide Fund for Nature–India (1988-96).

He presided over the Pugwash Conferences on Science and World Affairs which won Nobel Peace Prize.

The number of scientific papers he authored and co-authored will simply run into hundreds. Some of his books are 'Agro Biodiversity and Farmers' Rights' (1996), 'Implementing the Benefit Sharing Provisions of the Convention on Biological Diversity: Challenges and opportunities' (1997), 'Predict: A Century of Hope Towards an Era of Harmony with Nature and Freedom from Hunger' (1999), 'An Evergreen Revolution' (2006).

Both national and international awards and recognitions he received will run into several pages. Some of the international awards are:

Padma Vibhushan (1989), Ramon Magsaysay Award (1971), Four Freedoms Award (2000), Mendel Memorial Medal of the Czechoslova Academy of Sciences (1965), Borlaug Award (1979), Bicentenary Medal of the University of Georgia, U.S.A. (1985), Golden Heart Presidential Award of the Philippines (1986), the Albert Einstein World Science Award (1986), World Food Prize (1987), VOLVO Environment Prize (1990), Commandeur of the Order of the Golden Ark of the Netherlands (1990), The Tyler Prize for Environmental Achievement (1991), Honda Prize (1991), Charles Darwin International Science and Environment Medal (1993), World Academy of Art and Science (1994), Henry Shaw Medal by the Board of Trustees of the Missouri Botanical Garden, Ordre du Merite Agricole of Govt of France (1997), Highest award for International Cooperation on Environment and Development by Govt of China (1997), UNESCO Mahatma Gandhi Gold Medal (1999), Bennett Commonwealth Prize of the Royal Society of Arts.

A few of the National Awards are:

Shanti Swarup Bhatnagar Award (1961), Birbal Sahni Medal of the Indian Botanical Society (1965), Barclay Medal of the Asiatic Society (1978) , Moudgil Prize of the Bureau of Indian Standards (1978), Rathindranath Tagore Prize (1981), Meghnad Saha Medal (1981), Krishi Ratna Award by the Bharat Krishak Samaj (1986), Dr. J.C. Bose Medal, Bose Institute (1989), Lal

Bahadur Shastri Deshgaurav Samman (1992), B.P. Pal Memorial Award (1998), Jawaharlal Nehru Birth Centenary Award (1992), Asutosh Mookerjee Memorial Award for 1999-2000, Indira Gandhi Prize for Peace, Disarmament and Development (2000), Indian National Science Academy award (2001), Indira Gandhi Gold Plaque by the Asiatic Society (2002), Dupont-Solae Award (2004).

M S Swaminathan married Mina in 1951 when they were both studying at Cambridge. They have three daughters. He lives in Chennai.

Dr. Swaminathan is widely respected for his effective advocacy of sustainable development, especially using environmentally sustainable agriculture, sustainable food security and the preservation of biodiversity.

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MEGHNAD SAHA

(1893 - 1956 A.D.)

SAHA EQUATION

Renowned physicist Jayant Narlikar noted in his book 'The Scientific Edge':

"Meghnad Saha's ionisation equation, which opened the door to stellar astrophysics, was one of the top ten achievements of 20th century Indian science. It could be considered in the Nobel Prize class."

D. S. Kothari opines in Biographical Memoirs of Fellows of the National Institute of Sciences of India:

"Saha was extremely simple, almost austere, in his habits and personal needs."

Meghnad Saha was born on 6th October, 1893 in Sheoratali, a village now in Bangladesh. He was the fifth child of his parents Jagannath Saha and Bhubaneshwari Devi. His father was a poor grocer in the village. After early education in the local primary school, he had to pursue his middle school, seven miles away from his village. Even while working in a doctor's house near the school for his daily bread, he stood first in his class. While he was at the Dhaka Collegiate School, Bengal was reeling under agitation due to partition.

One day in 1905, when the then Bengal governor, Sir Bamfylde Fuller, visited his school, Meghnad boycotted the visit along with other students in protest against the division of Bengal. As a result, his scholarship was terminated and he was suspended from the school. He joined the Kishorilal Jubili School ranking first in the Entrance Examination of the Calcutta University in 1909.

In 1911, he passed the I.Sc. exam with third rank while the first rank went to Satyendranath Bose, who too became a great scientist. In a way, Meghnad Saha and Satyendranath Bose were friends as well as rivals in their studies. In 1913, he graduated from Presidency College ranking second in the University of Calcutta while S.N. Bose ranked first. However both stood first in M.Sc. exam in 1915 in separate branches of Mathematics. While studying in Presidency College, Meghnad met national leaders like Subhash Chandra Bose and Rajendra Prasad.

In 1917, Meghnad Saha started teaching Quantum Physics at the newly opened University College of Science in Calcutta (now Kolkata). Along with S.N. Bose, he translated Einstein's papers on 'relativity' from German into English. In 1919, American Astrophysical Journal published a research paper by Meghnad Saha, titled, 'On Selective Radiation Pressure and it's application'. This became famous as Saha Equation, which is an important tool in Astrophysics for interpretation of the spectra of stars. Astronomers could calculate temperature, pressure and other aspects of the interior of the sun or any other star with Saha's ionisation formula. Scientific American rated this equation as 'the foundation for the field of astrophysics.'

He toured abroad for two years in researches at Imperial College, London and in Germany. In 1927, Meghnad was elected as a Fellow of London's Royal Society. He was instrumental in the establishment of Uttar Pradesh Academy of Science in 1932. He returned to Science College, Calcutta (now Kolkata) in 1938 and brought Nuclear Physics into the curriculum of higher studies of science. In 1947, he established Institute of Nuclear Physics

which was later renamed as Saha Institute of Nuclear Physics. The institute had the distinction of India's first cyclotron in 1950 with Saha's efforts and initiative.

He was the founder and lifetime editor of the journal 'Science and Culture'. He was a man of undaunted spirit, untiring energy and dedication. He was the architect behind establishment of the National Academy of Science in 1930, the Indian Physical Society in 1934, Indian Institute of Science in 1935 and the Indian Association for the Cultivation of Science in 1944.

He presided over the 21st session of the Indian Science Congress in 1934. In 1952, he was elected for Parliament by a wide margin. Though he was a physicist by profession, the original plans for Damodar Valley, Bhakra-Nangal and Hirakud projects were prepared by him.

He bereaved all of us on 16th February, 1956.

"The impetus given to astrophysics by Saha's work can scarcely be overestimated, as nearly all later progress in this field has been influenced by it and much of the subsequent work has the character of refinements of Saha's ideas."

— Jayant Narlikar

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NIELS BOHR
(1885 - 1962 A.D.)

BOHR'S MODEL

During the Second World War, many European scientists fled their countries and shifted their base to America. This scientist was treated as a most precious commodity and a most dangerous consignment. He was to be transported in a special plane from Denmark in a British bomber.

On the plane, his seat was arranged on a trap door, such that in case of a German bomb attack the pilot could release a lever and drop the scientist down into the ocean. A cruel way of saving a scientist from the hands of Germans! The plane landed safely in London but the scientist was almost dead. Soon after take-off, he became so engrossed with a problem in Physics, that he did not hear the pilot's instructions to wear Oxygen mask. He fainted for lack of enough Oxygen at high altitude flying. He later quipped:

"An expert is a man who has made all the mistakes which can be made, in a very narrow field."

It is our fortune that Niels Bohr survived his costly mistake on that flight.

Bohr was born to Christian Bohr, Professor of Physiology at the University of Copenhagen and Ellen Adler Bohr, a wealthy

Jewish lady in Copenhagen, Denmark. His early life was fostered by the spirit of scientific enquiry and cultural heritage.

Hailing from such an intellectual ambience, it is no surprise then that he won gold medal from the Royal Danish Academy of Sciences and Letters in 1911. Bohr received his doctorate for a thesis on the Electron Theory of metals distinguished from the University of Copenhagen. He went to Cambridge, England, to study under Sir J.J. Thomson. As Sir Thomson did not evince any interest in Bohr's ideas on electrons in metals, Bohr joined Ernest Rutherford at Manchester.

After working as a Lecturer in Copenhagen and Manchester, he became a Professor in 1916. The University created Institute of Theoretical Physics specially for him in 1921, where he was the Director throughout his life. The Institute soon became an international nerve centre on Atomic Physics and the Quantum Theory. Three years after his death, the Institute was renamed as the Niels Bohr Institute. Bohr traveled widely most of the European countries, Canada and United States. He often joked:

"If Quantum Mechanics hasn't profoundly shocked you, you haven't understood it yet."

He was the first physicist to apply the Quantum Theory to the problem of atomic and molecular structure. During the 1930s, Bohr contributed to the new field of Nuclear Physics. He likened the nucleus to a liquid droplet and his liquid-drop model, the so-called Bohr theory of the atom and liquid model of the atomic nucleus, was important in understanding of many nuclear processes. In particular, it played a key role in 1939 in the Nuclear Fission (the splitting of a heavy nucleus into two parts, almost equal in mass, with the release of a tremendous amount of energy.)

He received the Nobel Prize for Physics in 1922. Bohr married Margrethe Norlund. One of his sons, Aage was also a Nobel Prize winner in Physics. They worked in England for several

months and then moved to Los Alamos, N.M. U.S.A. with a British research team. Einstein greatly admired Bohr's early work, referring to it as 'the highest form of musicality in the sphere of thought.'

When Denmark was occupied by the Germans by 1940, threat to his life became imminent because of his strong anti-Nazi views and his Jewish lineage. In 1943, he sailed to Sweden along with his wife and some other family members in a fishing boat in the dead of night with the help of Danish resistance movement. Then a few days later, Bohr was flown to England in an unarmed Mosquito bomber in a dramatic flight which almost cost him his life.

In 1944, he wrote to the British Prime Minister Winston Churchill and US president Franklin D. Roosevelt of the need for international cooperation in dealing with problems of nuclear proliferation. Bohr wrote his concerns in a public letter, 'Open Letter to the United Nations,' on 9th June, 1950. He promoted the First International Conference on the peaceful uses of Atomic Energy, held in Geneva (1955). European Council for Nuclear Research (CERN) was his brainchild. Bohr received the first 'US Atoms for Peace Award' in 1957.

Bohr himself was always ready to learn, even from his young collaborators. He attended a dinner in his honour at the University of Gottingen. A day before the big event, he visited a German graduate student and promptly invited him to join him at Copenhagen. The boyish looking young man was Werner Heisenberg who had already made significant advances in the field of quantum mechanics.

The element Bohrium is named in Neils Bohr's honour. He was the President of the Royal Danish Academy from 1939 until his death and President of the Danish Cancer Committee, and Chairman of the Danish Atomic Energy Commission. He was a Foreign Member of the Royal Society (London), the

Royal Institution, and a number of prestigious Academies all over the world.

Niels Bohr died in Copenhagen on 18th November, 1962.

Niels Bohr's brother was Harald Bohr, a mathematician and Olympic soccer player who played on the Danish national team. Niels Bohr was a passionate soccer player as well, and the two brothers played a number of matches for Akademisk Boldklub.

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NIKOLA TESLA
(1856 - 1943 A.D.)

ALTERNATING CURRENT

The letter of recommendation simply said, "I know two great men and you are one of them. This young man is the other". Edison without having a second look at the man, who brought the letter, employed him in his Edison Company. Great pair of men working together!!

Soon the young man commanded respect of Edison with his creativity and even proposed to completely re-design Edison's DC dynamos. Edison offered him $50,000 on successful completion. After successful completion and more new patents for Edison, the young man inquired about the promised $50,000.

Edison politely evaded paying it by saying, "Tesla, you don't understand our American humour!" Tesla walked off in disgust without uttering a word. That was the beginning of life-long rivalry and rift between the two giants.

Nikola Tesla was a physicist, inventor and electrical engineer of unusual intellectual brilliance and practical achievement. Tesla is most famous for conceiving the rotating magnetic field principle (1882) and inventing the induction motor and long-distance AC transmission system (1888). He also developed the fundamental principles and machinery of wireless technology, including the high frequency alternator, the 'AND' logic gate and, of course, the Tesla coil. He also developed a telephone repeater.

Tesla was born on 10th July, 1856 in Smiljan now in Croatia, to the Rev. Milutin Tesla, (a priest) and Mandi. Tesla went to school in Karlovac (now Croatia), then studied Electrical Engineering at the Austria Politechnic in Graz, Austria (1875). In 1881, he joined American Telephone Company at1 Budapest. Tesla became the Chief Electrician of the company and later became engineer to the Yugoslav government.

In 1884, Tesla arrived in the US with 4 cents in his pocket, a book of poetry, and a letter of recommendation from Charles Batchelor, manager in his previous job which he presented to Edison and got the job in Edison Company. In 1886, after the Edison episode, Tesla formed his own company, Tesla Electric Light & Manufacturing. But soon enough financial investors relieved him off his own company. Tesla then had to work as a common labourer from 1886 to 1887 in New York to feed himself and his next project.

In 1887, he constructed the initial brushless alternate-current induction motor, which he demonstrated to the American Institute of Electrical Engineers (now IEEE) in 1888. In the same year, he developed the principles of his Tesla coil and began working with George Westinghouse with his ideas on polyphase systems which can transmit AC electricity over large distances.

On 30th July, 1891, he became a naturalised citizen of the United States and established his 'Houston Street Laboratory' in New York. He lit vacuum tubes wirelessly, substantiating the potential of wireless power transmission. He developed cordless gas discharge lamps.

In St. Louis, Missouri, Tesla demonstrated radio energy crossing space from one side of a stage to the other in 1893. He discovered the concept of tuned electrical circuits. Tesla's four-tuned circuits were the basis of the US Supreme Court decision to overturn Marconi's basic patent on the invention of radio. In 1905, he wrote the following lines in his article, 'The Transmission of Electrical Energy without Wires as a means of furthering World Peace':

"So astounding are the facts in this connection, that it would seem as though the Creator, Himself had electrically designed this planet."

DC power transmission expounded by Edison was used in those days. Nikola Tesla and Thomas Edison became adversaries due to Edison's promotion of Direct Current (DC) against Tesla's more efficient Alternating Current (AC). But in 1893, Tesla and George Westinghouse illuminated World's Fair, the World Columbian Exposition in Chicago, Illinois, with AC power. In a remonstration, Edison did not allow any of his light bulbs for this event.

Tesla always felt:

"Of all the frictional resistances, the one that most retards human movement is ignorance, what Buddha called the greatest evil in the world. The friction which results from ignorance can be reduced only by the spread of knowledge."

Tesla and Edison developed characteristic disdain for each other. As a result of this 'War of Currents' Westinghouse became almost bankrupt. In a humane touch, Tesla simply tore the contract papers and released Westinghouse of the royalties due to him from his AC motor in 1897.

In 1899, Tesla began research in Colorado Springs, Colorado for his high-voltage high-frequency experiments. The lab possessed the largest Tesla Coil ever built; Tesla became the first man to create electrical effects on the scale of lightening. Tesla left Colorado Springs on 7th January, 1900. The lab was torn down, broken up, and its contents sold to pay the debts.

Tesla was a man of vision who saw beyond the realm of third dimension, a genius among geniuses. He had a lifelong friendship with Mark Twain. Tesla served as the Vice-President of the American Institute of Electrical Engineers from 1892 to 1894. His researches in Electricity were enormous with over 700 patents. They are so novel that none could ever challenge them in the courts.

He died on 7th January, 1943.

One day in 1882, while walking with a friend in a Belgrade park, Tesia suddenly froze. His friend tried to make him sit on a bench, but Tesla refused. He traced a drawing of a new AC motor design in the sand then and there. Six years later, Tesia presented the drawing again, but this time before the American Institute of Electrical Engineers as a new scientific principle of stunning simplicity and utility.

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"If Edison had a needle to find in a haystack, he would proceed at once with the diligence of the bee to examine straw after straw until he found the object of his search. I was a sorry witness of such doings, knowing that a little theory and calculation would have saved him ninety per cent of his labor."

NORMAN BORLAUG

(1914 A.D....)

AGRICULTURAL SCIENTIST

Biologist Paul R. Ehrlich wrote in his bestseller 'The Population Bomb':

"The battle to feed all of humanity is over... In the 1970s and 1980s, hundreds of millions of people will starve to death in spite of any crash programs embarked upon now.....I have yet to meet anyone familiar with the situation who thinks India will be self-sufficient in food by 1971...India couldn't possibly feed two hundred million more people by 1980."

Obviously he did not meet Dr. Borlaug, who saved hundreds of millions of starving people from certain death. It is only appropriate in awarding the Nobel Peace Prize for him in 1970 as there would be no peace in the face of stark hunger.

Borlaug was born to Henry Oliver and Clara Borlaug on 25th March, 1914. He attended the one-teacher, one-room school up to eighth grade. After his high school, he worked as a farm hand for 50 cents a day to pay for his college and joined the University of Minnesota in 1933. A lecture by Dr. Elvin Stakman, the Head of the University's Plant Pathology Department, inspired him so much that he ran to request him for his induction to the Ph.D program in Plant Pathology, which he received in 1942. It was a decision that saved billions of people.

He met his wife, Margaret Gibson, while in college, when both were working as waiters at a University coffee shop. They had two children. From 1942 to 1944, Borlaug worked as a microbiologist at DuPont in Wilmington, Delaware heading research on bactericides, fungicides, etc. Upon a request from the Army, he developed saltwater resistant glue within weeks, which helped in sending supplies to stranded marines.

He actually rejected an offer from DuPont to double his salary and reached Mexico City to head a joint undertaking by the Mexican government and the Rockefeller Foundation as a Geneticist and Plant Pathologist in July 1944, temporarily leaving behind his pregnant wife and 14-month old daughter. In those difficult times, he faced hostile farmers, dearth of trained scientists and equipment. Cross breeding almost 6000 varieties, he saw Mexico becoming fully self-sufficient in wheat production, and a net exporter of wheat.

In 1964, he became the director of the International Wheat Improvement Program of Consultative Group on International Agricultural Research's International Maize and Wheat Improvement Center (CIMMYT) near Mexico City and developed semi-dwarf high-yield, disease-resistant wheat varieties.

Inspired by his breakthrough achievements, in May 1962, India's M. S. Swaminathan, prevailed on the government to invite Borlaug to the country. Repeating the success, crop yields in India increased four folds and India became self-sufficient. In recognition of the green revolution, The Government of India conferred the Padma Vibhushan, its second highest civilian award on him in 2006. Success stories from Pakistan, China, African and Arabian countries were pouring. He is one of the earliest scientists from West to visit China.

True to 'Borlaug hypothesis' that increasing the productivity of agriculture on the best farmland can help control deforestation by reducing the demand for new farmland, thousands of square kilometers of virgin land was protected. Offshoot of his researches led to the development of high-yield semi-dwarf rice at the International Rice Research Institute, at China's Hunan

Rice Research Institute and at the Consultative Group on International Agricultural Research.

On 20th October, 1970, when the phone call came from Sweden, he was in a far off farm field in Mexico. Margaret Borlaug drove for over an hour to break him the news. Excitedly, she yelled, "You won the Nobel Peace Prize." He said, "No, I haven't.." He did not believe the news as there was no Nobel Prize for Agricultural Science.

This 'Father of the Green Revolution' was awarded the prize on 10th December 1970. He is the only agricultural scientist ever to receive the Nobel Peace Prize. He saved more human lives than any other person in history. In his Nobel lecture, Borlaug said:

"Most people still fail to comprehend the magnitude and menace of the 'Population Monster'.....There can be no permanent progress in the battle against hunger until the agencies that fight for increased food production and those that fight for population control unite in a common effort."

Shortly after receiving the Peace Prize, he urged the Nobel Committee to create a Nobel Prize for Agriculture; they said it was not possible. So in 1986, he established the World Food Prize to recognize the individuals who have advanced human development by improving the quality, quantity or availability of food in the world. The first prize was given in 1987 to M. S. Swaminathan for his pioneering work in India. Swaminathan said, "Norman Borlaug is the living embodiment of the human quest for a hunger free world. His life is his message."

He authored several books like 'Wheat in the Third World', 'Land Use', 'Food', 'Energy and Recreation'. He became a member of the U.S. National Academy of Sciences. In 1984, his name was placed in the National Agricultural Hall of Fame at Kansas. Borlaug has also received the 1977 U.S. Presidential Medal of Freedom, the 2002 Public Welfare Medal from the U.S. National Academy of Sciences. At the last count, Borlaug had received

about 50 honorary degrees from various universities and was honorary member of international Academies of Sciences. Several streets, research institutions and buildings have been named in his honour. In 2006, the Texas A&M University created the Norman Borlaug Institute for International Agriculture.

America's highest civilian award, the Congressional Gold Medal was presented on 17th July, 2007. 16th October is celebrated as 'World Food Prize Day'.

Recalling his wrestling days at the University of Minnesota, he said, "Wrestling taught me some valuable lessons ... I always figured I could hold my own against the best in the world." He was inducted into the National Wrestling Hall of Fame in Stillwater in 1992.

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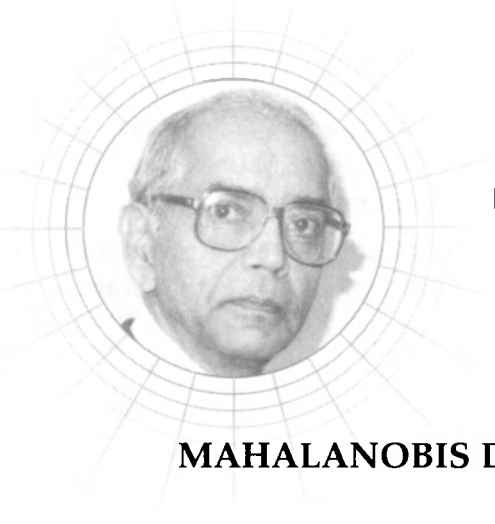
"You can't build a peaceful world on empty stomachs and human misery."



P. C. MAHALANOBIS
(1893 - 1972 A.D.)

MAHALANOBIS DISTANCE

Mahalanobis was busy reading a book in the library of King's College, Cambridge when a certain Macaulay met him with some volumes of the book Biometrica, edited by Karl Pearson. He sought Mahalanobis opinion on the books. Biometrica caught his interest so much that he purchased the entire set. That was the beginning!!

Data collected by Mahalanobis paved the road for the creation of the second five-year economic plan and rapid industrialisation of India. Indian Statistical Institute was founded by him on 17th December, 1931. He developed the famous Mahalanobis distance, a tool for statistical (non-physical) distance measurement. In 1957, he chaired International Statistical Institute as Honorary President.

Prasanta Chandra Mahalanobis was born in Calcutta (now Kolkata) on 29th June, 1893 to Prabodh Chandra and Nirodbasini. He had his early education at the Brahmo Boys School and completed Bachelor of Science degree in Physics from the Presidency College in Calcutta (now Kolkata) in 1912. He then reached the shores of England and joined Cambridge University. He finished Tripos at King's College, Cambridge.

After returning to India, he was offered a position to teach Physics at the Presidency College. His first love was Statistics, though he continued teaching Physics until 1948. He started with analysis of University exam results. He made anthropometric study on Anglo-Indians of Calcutta. He was a meteorologist for some time and worked on some meteorological problems.

He worked on the probability error of results in agricultural experiments and schemes to prevent floods. He developed the sampling methods and concept of pilot surveys and importantly large scale sample surveys. He developed the famed 'The Mahalanobis Distance', the scale-free multivariate distance measure, called the D Statistic in 1936 while making his anthropometrical studies.

He not only founded Indian Statistical Institute but he also established National Sample Survey (NSS), a division within the ISI. He continued his researches there as the Secretary and Director until a very ripe period of his life. NSS is now a part of the Ministry of Planning. He was an Honorary Statistical Advisor to the Cabinet of the Government of India till his death.

He was right hand man for Pandit Jawahar Lai Nehru for his Five Year Plans. He received Weldon Medal from Oxford University in 1944 and was nominated as Fellow of the Royal Society in 1945.

'Sankhya,' a journal in statistics was started by him and he wrote a number of scientific non-technical articles in Bengali and English. Published articles alone would add up to 200. In 1957 he chaired International Statistical Institute as Honorary President.

Government of India conferred on him the highest civilian award, the Padma Vibhushan in 1968. He worked at Vishva-Bharati University for some time and Rabindranath Tagore was his close friend for whom he acted as a Secretary particularly during Tagore's foreign tours. In 1924, he became friends with Ronald Fisher. This friendship lasted a life time.

His birthday, 29th June, was declared as National Statistical Day. Leaving a legacy of invaluable statistical data and methods, he left us on 28th June, 1972, a day before his seventy-ninth birthday.

Meeting of Two Great Mathematicians:

Dr. P. C. Mahalanobis was already a student at Cambridge when Ramanujan joined it. Mahalanobis went to Ramanujan's room for lunch at the latter's invitation. As Ramanujan was still cooking, Mahalanobis started reading the Strand magazine lying nearby. A problem in the puzzle section attracted Mahalanobis and he was soon deep into it. He solved the problem in a few minutes and asked Ramanujan to crack it. While still stirring the pan, Ramanujan asked for the problem. Hardly had Mahalanobis finished his question, Ramanujan dictated the answer.

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PHILO FARNSWORTH
(1906 - 1971 A.D.)

ELECTRONIC TELEVISION

A 14-year-old farm boy showed complicated sketches and equations written across the blackboard to his Chemistry teacher, Justin Tolman in March 1922. The boy showed it to Tolman as he thought that his teacher was the only person who can understand it.

The teacher asked the boy, "What is this to do with Chemistry?"

The boy answered, "This is my idea for electronic television."

His teacher was startled and asked, "Television? What's that?"

His ideas were farfetched at that time as only a handful of men on this planet could have understood an electronic-television system.

But on 7th January, 1927, he applied for his first patent. On 7th September, 1927, he watched a black horizontal line on television receiver built from a chemistry flask. His method of picture scanning is still followed. This is the story of an inventor and his oblivion. He was a persuasive inventor and also a bitter critic of the idiot box.

Farnsworth was born on 19th April, 1906 to Lewish Edwin and Serena Bastian Farnsworth at Indian Creek, near Beaver City, Utah. This young American farmer dreamt of a device that could project images transmitted through the air. His inspiration came in 1922 while he was tilling a potato field back and forth. He thought of capturing the light in a jar, magnetically scan the picture into individual lines just as you read a book and transmit it in a series of electron beams. He wanted to reconstruct the exact picture, the same way.

Ideas are great but need of the day is money. His friend George Everson agreed to finance $6000 to test his idea. Phil, in the meantime, fell in love with George's sister, Pem and married her. They moved to the suburbs of Hollywood. Dining room was his laboratory.

On 7th September, 1927, Pem, George, and Cliff saw a black horizontal line. When the slide with horizontal line was rotated the image also rotated. Television was born in a chemistry flask!

The San Francisco Chronicle published an article with a photo of Farnsworth, titled 'SF Man's Invention to Revolutionise Television'. Unfortunately soon after this publication, his equipment at 202 Green Street was lost in a fire. Farnsworth quickly rebuilt the laboratory.

Radio Corporation of America (RCA) was frantically trying to develop television but was not inclined to pay royalties to Farnsworth. Vladimir Zworykin, a Russian emigre with a Ph.D in Electrical Engineering visited Farnsworth's Labs under the guise of a fellow researcher. Watching the invention, Zworykin exclaimed, "This is beautiful. I wish I had invented it." Zworykin could not really reverse engineer it even after spending full three days with Farnsworth. Then RCA offered Everson a staggering $100,000 for the rights. But Everson and Farnsworth rejected the offer. RCA dragged him to courts.

He had to spend most of his adult life in a legal fight with one of America's largest and most powerful corporations. His

old school teacher, Justin Tolman walked into the court rooms to testify that Farnsworth conceived the idea as a 14-year-old boy. Tolman even produced the original sketch of an electronic tube that Farnsworth had drawn for him in the school. The sketch was almost an exact replica of an image dissector Farnsworth invented. In April of 1934, the patent office ruled in favour of Farnsworth. RCA appealed and lost.

He moved to Philadelphia. The first film to be broadcast on his invention was Walt Disney's 'Steamboat Willy', of course without breaks for commercials. In 1934, Farnsworth sailed for Europe to strike deals and returned with $50,000 in cash. In 1935, he held the first public demonstration of television at the Franklin Institute in Philadelphia. With a camera near the door, the visitors were able to see themselves on the nearby receiver, the bottom of a ten gallon jug. It was a huge success. Franklin D. Roosevelt was the first American President to be aired on television in April 1939.

After the expiry of Farnsworth's over 100 patents, RCA started capitalising on them without paying a cent. He had to sell his assets to International Telephones and Telegraph in 1949. He became disillusioned, suffered a nervous breakdown and remained bedridden. He moved to Maine and became an alcoholic. His greatest moment came when he and his wife Pem watched the first moonwalk in 1969 on television.

The New York Times described him as a reserved, slender, quiet and unassuming man tirelessly absorbed in his work. At the age of 31, he was rated by competent appraisers as one of the ten greatest living mathematicians.

TIME magazine named him as one of the 100 Greatest Scientists and Thinkers of the 20th century.

Farnsworth died on 11th March, 1971.

To sum up the story with his own quote:

"We must not lose track of the fact that inventions as such, important inventions, are made by individuals and almost invariably by individuals with very limited means."

In his late years, he appeared as Dr. X on a television program titled 'What's My Line?' The members of the panel were required to identify and justify the presence of Dr. X on the television. One of them enquired if he had invented a machine that becomes painful when used. Farnsworth answered, "Yes. Sometimes it's most painful." None could recognise the man who invented the marvel, they were appearing on.

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RAJA RAMANNA

(1925 - 2004 A.D.)

NUCLEAR PHYSICIST

Recalling his first meeting with Homi Bhabha, Raja Ramanna wrote:

"One day, in 1944, Dr. Mistowski (an examiner from the Trinity College of Music) told me that there was a famous Indian scientist and his mother spending their vacation in the state guest house and wondered whether, I, a science student, would like to meet them. He said the scientist was also interested in music, especially in Mozart.

'But,' Dr. Mistowski said, 'You must, of course, know him. His name is Homi Bhabha.'

Little did I know that my meeting with Bhabha would determine the course of the next several years of my life."

That was the beginning of a long fruitful association which saw the growth of indigenous nuclear capabilities, technological developments and an array of accomplished scientists in India. Raja Ramanna was a versatile genius, a distinguished nuclear physicist, a competent administrator, a high technologist, an inspirational leader, an accomplished musician, and a Sanskrit scholar — all packed into one.

Ramanna was born in Tumkur in Karnataka on 28th January, 1925 to B. Ramanna and Rukminiamma. He had his early schooling at the Bishop Cotton School, and intermediate studies at St Joseph's, Bangalore. He had his B.Sc (Hons) degree in Physics from Madras Christian College. He went to England as Tata Scholar and obtained his Ph.D degree in 1948 in Nuclear Physics at the King's College, London.

Ramanna joined Tata Institute of Fundamental Research on 1st December, 1949 after his Ph.D when Homi Bhabha offered him a job there. Interestingly, Bhabha allotted him two adjacent rooms — one for Ramanna and the other for his piano.

Ramanna was a young reactor physicist in Bhabha's team, when India's first research reactor, Apsara, was commissioned on 4th August, 1956. Ramanna made several salient contributions in organising Physics and Reactor Physics programmes at the Bhabha Atomic Research Centre, Trombay. His group contributed to geometrical interpretation of atomic and nuclear binding energies. He generated a vast pool of trained scientific manpower from BARC Training School, which also helped to a great extent in stalling the so-called brain drain. While complimenting creativity and encouraging the excellence, he cut pretentious presentation mongers to size.

In the early 1980s, he initiated steps for Centre for Advanced Technology at Indore, devoted to the development for advanced accelerators, lasers, etc. and the Variable Energy Cyclotron Centre (VEC) at Kolkata. He was the founder-director of the National Institute of Advanced Studies (NIAS) at Bangalore established by J.R.D. Tata. He was the Chairman of the Board of Governors of the Indian Institute of Technology, Bombay (1972-78) and Chairman of Scientific Advisory Committee to the Director General.

As an able administrator, he held prestigious positions as the Director of the Bhaba Atomic Research Centre (1972-78 and 1981-83). He was Scientific Advisor to the Minister of Defence; Director-General, DRDO and Secretary for Defence Research,

Government of India (1978-81). He was Vice President of Indian Academy of Sciences (1977-79); President of Indian National Science Academy, New Delhi (1977-78) and President of General Conference of Atomic Energy Agency, Vienna (1986).

He was a nominated Member of the Parliament, Rajya Sabha, (August 1997-August 2003) and Minister of State for Defence in the Union Cabinet (January to November 1990). Some of the awards he received were: Shanti Swarup Bhatnagar Award (1963), Padma Vibhushan Award (1975), Meghnad Saha Medal of the Indian National Science Academy (1984), R.D. Memorial Award (1985-86), Asutosh Mookerjee Gold Medal (1996). A number of universities conferred honorary doctorates on him.

Among his important contributions, in theoretical and experimental Nuclear Physics, India's first peaceful nuclear experiment conducted underneath the earth at a selected spot in Rajasthan desert on 18th May, 1974 stands out. Recalling that peaceful nuclear explosion, he said:

"The Pokhran experiment was a landmark in the history of nuclear research in the country. It was an assertion of the technological advancement India had determined to perfect in the post-independence era."

He himself was a gifted musician. He wrote a book on music, 'The structure of Music in Raga and Western Music.' Bangalore School of Music was the result of his active involvement. His other interests were philosophy and yoga. He had a fine sense of humour.

Ramanna died on 24th September, 2004 at Mumbai after a cardiac arrest.

As P.K. Iyengar pointed out:

"Ramanna's more important legacy is his uncompromising belief in intellectual clarity and rational thinking in every facet of life, and his unwavering belief that the nation could progress only by embracing science and scientific thinking."

Krisnaraja Wadiyar, the then Maharaja of Mysore patronised classical music - Carnatic, Hindustani and Western. Recalling his meeting with the Maharaja, Ramanna wrote:

"Word reached him through various sources that I could play the piano well and an audition was fixed for me at the Jaganmohan Palace in 1937. On the day of the audition, the Maharaja listened intently to new set pieces that I played for him. Later, he came up for a chat and asked whether my teachers were guiding me properly and whether they discriminated between me and the European children. I was touched; the Maharaja was genuine in the care he showed towards a twelve-year-old."

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ROBERT H. GODDARD

(1882 - 1945 A.D.)

ROCKET PIONEER

In the year 1929, on a cool morning, the newspapers screamed:

"Moon rocket misses target by 238,799 1/2 miles."

On 16th March, 1926, a scientist set up a ten-foot rocket in his aunt's field and signaled his assistant to light its fuse. Nothing happened and as he was scratching his head wondering what went wrong, the rocket lifted off the ground at 60 miles per hour (about 96 km/h). After reaching a height of 41 feet (12.5 meters), it plummeted downward and slammed into a frozen cabbage patch 184 feet (56 meters) away. The entire flight lasted just 2 ½ seconds, but that 2 ½ seconds was longer than any liquid-fueled rocket had ever flown before.

Three years later, in 1929, as he set up an eleven-foot rocket, police were called in. If police came, would the press stay behind?

The next day the papers screamed sarcastically that the rocket crashed in less than a mile:

"Moon rocket misses target by 238,799 1/2 miles."

Clock back to ten years, in 1919, the Smithsonian Institution published a path-breaking book, 'A Method of Reaching Extreme Altitudes'. The book narrated mathematical theories of rocket flight, researches in solid-fuel and liquid-fuel rockets, and the possibilities of exploring the Earth and beyond.

The New York Times, on 12th January, 1920 reported this with a front-page story, 'Believes Rocket Can Reach Moon'. The next day, the newspaper made a scathing attack on the scientist and his theories condemning him as deficient in the knowledge doled out daily in High Schools.

Forty years later, on 14th September, 1959 the Soviet space probe Luna 2 reached the Moon. Ten years later, in 1969, the Apollo spacecraft landed on the moon, at about 238,800 miles (384,311 kilometers) from the Earth. The New York Times officially regretted that error made by them in 1929.

The scientist behind all these stories was the father of modern rocket propulsion, Dr. Robert Hutchings Goddard. He was born in Worcester, Massachusetts to Nahum Danford Goddard and Fannie Louise Hoyt as their only child on 5th October, 1882.

H.G. Wells's science fiction classic 'The War of the Worlds' inspired him when he was just 16 years old. While on a cherry tree, he imagined, 'How wonderful it would be to make some device which had even the possibility of ascending to Mars.' 19th October was the day when the inspiration struck him. It was observed by him as 'Anniversary Day.'

Fragile that he was, Goddard fell two years behind in his school, but he was a voracious reader, and a regular visitor to the local public library. He joined Worcester Polytechnic Institute in 1904, where he received his B.S. degree in physics in 1908. He had an instinct for pyrotechnics and to their credit the Institute allowed him to carry out experiments from their Magnetics Lab. At his graduation ceremony in 1904, he prophetically said:

"It has often proved true that the dream of yesterday is the hope of today, and the reality of tomorrow."

He received his M.A. degree from Clark University in 1910, and his Ph.D in 1911. He continued at Clark University as an

Honorary Fellow in Physics until he became a Research Fellow at Princeton University in 1912.

In 1914, he took up a part-time teaching position at Clark University after recovering from tuberculosis. That year, Goddard received two US patents, one for a liquid-fuel rocket and the other for multistage rocket using solid fuel. By 1916, the cost of his rocket research was becoming unbearable from his modest income. So he solicited financial assistance and got a five-year grant of $5,000 from the Smithsonian Institution. He was the butt of jokes among his colleagues, but his rockets grew up to 18-foot, and their altitude reached 9,000 feet. He built rockets that crossed the speed of sound and developed fin-stabilised steering, gyro-controls and pumps for rocket fuels.

Goddard launched the first liquid-fueled rocket on 16th March, 1926 in Auburn, Massachusetts. The launch site is marked now as a national historic landmark, the Goddard Rocket Launching Site. His rocket flight in 1929 even carried the first scientific payload, a barometer, and a camera.

Charles Lindbergh became his friend for life and was influential in gaining funds researches from the Daniel and Florence Guggenheim Foundation for $100,000. He also received another $10,000 from the Smithsonian by 1927.

With new financial assistance, Goddard moved to Roswell, New Mexico. His own observations indicated that of all the countries, Germany was showing most interest in his rocketry. So he visited Army Headquarters in Washington along with some films of his various rockets. As the generals were watching the films, he told them:

"We could slant it a little and do some damage."

Unfortunately, the officers gave a cold smile and failed to understand the military implication of rockets. Ironically, it was Nazi Germany that took interest in Goddard's plans from various journals and patent papers. German pioneers Hermann Oberth and Wernher von Braun were influenced by Goddard's book.

Robert H. Goddard's contribution to rocketry and missilery is an eloquent testimonial to the present conquests of space. He was awarded 214 patents for his work, including a vacuum tube that operated like a cathode-ray tube, the first use of a vacuum tube to amplify a signal, even before Lee de Forest.

He died on 10th August, 1945 due to throat cancer in Baltimore, Maryland four days after the first atomic bomb was dropped on Japan.

The Goddard Space Flight Center, established in 1959, Greenbelt, Maryland, is named in his honour.

Goddard crater, on the moon, is also named in his honour.

Germany's lethal V-2 rockets, about 1100 of them, ruined London in World War II. When a captured German scientist was inquired about the V-2, he answered, "Why don't you ask your own Dr. Goddard? He knows better than any of us."

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ROBERT NOYCE
(1927 - 1990 A.D.)

INTEGRATED CIRCUIT

Shockley called them 'Traitorous Eight'. Seven of the young researchers at Shockley Semiconductor decided to leave the company when they could no longer stand the mortifying behaviour of their boss. All of them zeroed in on Noyce, still young at 29 as their leader. Noyce was the eighth in the group that left Shockley in 1957 and founded Fairchild Semiconductor.

Robert Noyce was nicknamed 'Mayor of Silicon Valley'. At Fairchild, Noyce invented the integrated circuit, the silicon chip, where a number of transistors and passive components are etched in a single piece, which proved a stepping stone for Microelectronics. He left Fairchild in 1968 to establish Intel with Gordon Moore (remember Moore's Law). At Intel, he was behind Ted Hoff's invention, the microprocessor. Electronics was no longer the same again, first with Integrated Circuit and then with Microprocessor. He was already there and running two companies much before silicon really invaded the valley and our lives.

The third revolution, he transformed the way American corporate worked from the model he managed the two companies. Noyce felt:

"The people that are supervising a project are more dependent on their ability to judge people than they are dependent on their ability to judge the work that is going on,"

He avoided Shockley's mistakes. He established a very casual and open working environment, where his brilliant young employees enjoyed working and worked with responsibility.

Robert Noyce was born on 12th December, 1927 in Burlington, Iowa to Ralf, a preacher and Harriet. He graduated with a B.S. in Physics from Grinnell College in 1949. His professor managed to get hold of two of the very first transistors ever made from Bell Labs and showed them to the eighteen students majoring in Physics at Grinnell College. Noyce was one of the eighteen. This spurred his interest in electronics and thus began a lifelong pursuit. That helped him know more about transistors than most of his professors at Massachusetts Institute of Technology knew, while he was doing his Ph.D.

He received Ph.D in Physics from MIT in 1953, with a dissertation on 'Photoelectric Study of Surface States on Insulators'. Early in 1953, after his Ph.D he went over to Tufts College to participate in a musical, where he met the costume director named Elizabeth Bottomley. Both had common interests. They fell in love and got married that fall.

For some time he worked with Philco making transistors and then shifted to Shockley Semiconductors. He left Shockley in 1957 and founded Fairchild Semiconductor. Fairchild Semiconductor filed a patent for a Semiconductor Integrated Circuit based on the planar process on 30th July, 1959. But Texas Instruments had already filed a comparable patent with Kilby's IC some time before. After a decade long legal battle, the US Court of Customs and Patent Appeals sustained Noyce's claims on interconnection techniques but gave Kilby and Texas Instruments credit for the first working integrated circuit.

In a historical coincidence both invented the Integrated Circuit (IC) without knowing each other and about the same time. Noyce's silicon IC is more efficient, more practical and the most common form now. NASA used Noyce's Integrated Circuits

for the first computers in the spacecraft of the Gemini program. His small town upbringing brought him up as an inventor, an engineer, a technician, and a tinker. Noyce remarked:

"In a small town, when something breaks down, you don't wait around for a new part, because it's not coming. You make it yourself."

After twenty-one years of marriage, Noyce divorced his wife Betty and at the age of forty-seven, he married Intel's personnel director, Ann Bowers, who was thirty-seven years old.

Intel headquarters building is named after him - Robert Noyce Building. Science division of Grinnell College where he studied was also named after him. Institute of Electrical and Electronics Engineers (IEEE) awarded him the Medal of Honor in 1978 for his contributions to the silicon integrated circuit, a turning point of modern electronics.

During one of the last interviews he was asked what he would do if he were emperor of the United States. He answered that he would, among other things, make sure we are preparing our next generation to flourish in a high-tech age. And that means education of the lowest and the poorest, as well as at the graduate school level.

In this world of games of jealousy and clash of egos, final tribute for the genius comes from the autobiography of none other than Jack Kilby where he acknowledged his participation in inventing the Integrated Circuits. Noyce did not live to share the prize with Kilby.

Someone said, "Noyce is a national treasure." He was wrong. We lost an international treasure when he died of heart failure on 3rd June, 1990 at the age of 62.

During his college days at Grinnell, he stole a pig and got it slaughtered in the Clark hall. He offered to pay for the prank. He was almost expelled from the college but for the intervention of his physics Professor, Grant O. Gale. □□

RONALD ROSS
(1857 - 1931 A.D.)

MALARIA CURE

When he was still a medical student in London, this Indian-born British scientist diagnosed a woman as suffering from malaria. The disease was unusual in a country like England as it was only found in hot tropics. However, he could not really treat her as the woman ran away after hearing the detailed diagnosis. He was a small boy when he saw many people in India fall ill with malaria. His father, too, fell seriously ill with malaria thereafter, but fortunately survived. These experiences stirred his interest in malaria and he constantly tried to find the link between malaria, mosquitoes and medicines.

He faced administrative indifference, interference and apathy, (administrative barbarism) throughout his career. He transformed hardship to help and overcame the difficulties with a single-minded dedication to his research; in a profession he was initially reluctant.

His plight in the research can be best explained in his own words:

"But the weather became very hot again in August. At first I toiled comfortably, but as failure followed failure, I became exasperated and worked till I could hardly see my way home late in the afternoons. Well do I remember that

dark hot little office in the hospital at Begumpett, with the necessary gleam of light coming in from under the eaves of the veranda. I did not allow the punka(fan) to be used because it blew about my dissected mosquitoes, which were partly examined without a cover glass; and the result was that swarms of eye-flies, the minute little insects which try to get into one's ears and eyelids, tormented me at their pleasure, while an occasional stegomyia revenged herself on me for the death of her friends. The screws of my microscope were rusted with sweat from my forehead and hands, and its last remaining eye-piece was cracked."

Ronald Ross was born on 13th May, 1857, in the ravaging times of the Indian Sepoy Mutiny as the son of Sir C.C.G. Ross, a General in the English Army posted at Almora, India, where he lived until he was eight. He studied medicine at St. Bartholomew's Hospital in London in 1875; entered the Indian Medical Service in 1881. At school, he was a 'dreamy boy' writing poetry, painting and composing music. In his own words:

"I wished to be an artist, but my father had set his heart upon my joining the medical profession."

He worked on malaria in Calcutta (now Kolkata) at the Presidency General Hospital. Ross was more and more worried of medical problems in India of which malaria was his chief concern. He wrote:

"I was neglecting my duty in the medical profession but I had harnessed all my energies towards bettering mankind by trying to discover the causes of those diseases which are perhaps mankind's chief enemies."

At that time it was general belief that breathing in bad air in a hot, marshy country caused malaria (male means bad and aria means air).

In 1883, Ross was posted as the Acting Garrison Surgeon at Bangalore. In his otherwise pleasant bungalow, he was frequently irritated by the music of mosquitoes. Inquisitive as he always was, he went around and saw a large swarm of them

around a water tub and wriggling mosquito larvae inside the tub. Then he realised that by removing the breeding grounds, mosquitoes can be eliminated.

Sir Patrick Manson, the foremost authority on tropical diseases in London, encouraged and guided Ross throughout his research. In 1894, one November afternoon at half-past two, Manson confided:

"Do you know, I have formed a theory that mosquitoes carry malaria just as they carry filaria."

In March 1897, Ross fell ill with malaria in Ootacamund and then he was transferred to Secunderabad where cholera struck him. He wrote to his wife saying:

"I have failed in finding parasites in mosquitoes fed on malaria patients, but perhaps I am not using the proper kind of mosquito."

Then he found them, the mosquitoes with their wings covered with little spots or dapples. He was a very shrewd observer who nosed his way through his elegant experiments with a pure instinct. Ross inflicted a malaria patient named Husein Khan with female mosquitoes (only females suck blood) on a payment of one anna per mosquito bite. The volunteer collected ten annas which was a huge sum those days. By 20th August, Ross had dissected mosquitoes, saw malaria parasites under a microscope as a clear and almost circular outline. Hence 20th August came to be known as Mosquito Day.

In 1899, Ross joined Liverpool School of Tropical Medicine as a professor of tropical medicine. He traveled to West Africa and found the species of mosquitoes causing the deadly African fever. In 1901, Ross was elected a Fellow of the Royal College of Surgeons and also a Fellow of the Royal Society, of which he became Vice-President from 1911 to 1913. Sir Ronald Ross received many honours in addition to the Nobel Prize for Physiology in 1902 (the second ever) for his remarkable work on malaria. In 1911, he was knighted. He was made an Officer in the Order of Leopold II in Belgium.

He ascertained the life cycle of the malarial parasite, and demonstrated the disease's mode of transmission to humans from infected birds to healthy ones by the bite of a mosquito. He carried out surveys and initiated organisations for the prevention of malaria not only in India and Ceylon but other countries as well. His greatest contribution was the development of mathematical models in epidemiology. A genius much beyond his mosquitoes and mathematics, he was also a poet, playwright, writer, musician and painter. He wrote a number of poems and novels like — The Child of Ocean, The Emigrants, The Judgement of Tithonus, The Revels of Orsera and The Spirit of Storm. His autobiography, 'The Memoirs' was published in 1923.

He got an honorary M.D. degree in Stockholm in 1910. He had a vast circle of friends and admirers all over in Europe, Asia and America. In 1926, his admirers built the Ross Institute and Hospital of Tropical Diseases and Hygiene for him in which he was the lifetime Director-in -chief. He was also a President of the Society of Tropical Medicine.

In India, Sir Ronald Ross is much respected, with roads and buildings named after him. In Kolkata, the earlier Hospital Road is now known as Sir Ronald Ross Sarani. The Institute at Secunderabad where he had discovered the anopheles mosquitoes as the cause of malaria is renovated and declared as a National Heritage Monument.

He married Rosa Bessie Bloxam in 1889. They had two sons and two daughters. His wife died in 1931. Next year, he too died on 16th September at the Ross Institute after a prolonged illness.

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S. CHANDRASEKHAR
(1910 - 1995 A.D.)

CHANDRASEKHAR'S LIMIT

In 1946, a boyish-looking man drove at least once every week from Yerkes Observatory in Wisconsin to the University of Chicago, a distance of 160 kilometers, to teach only two students. Many wondered why he took so much trouble to teach just two students and why these students wanted this particular teacher only.

They got their answer when in 1957 these two students, Tsung Dao Lee and Chen Ning Yang, were awarded the Nobel Prize in Physics. And their teacher was Subrahamanyan Chandrasekhar, one of the world's leading astrophysicists.

Chandrasekhar was born on 10th October, 1910, in Lahore (now in Pakistan). His father Chandrasekhara Subrahmanya Ayyar was a Deputy Auditor General with the Northwestern Railways. Chandrasekhar's mother Sita Ayyar was an intellectual and his father was a well-acclaimed Carnatic music violinist. Nobel Prize winner C. V. Raman was his uncle. Chandra was inspired by the mathematical accomplishments of S. Ramanujan.

Between 1922-25, Chandrasekhar attended the Hindu High School, Triplicane, Madras. He finished his B.A. (Hons) at the Presidency College in Madras in 1930. With an insatiable urge

for reading, he completed every book in the local library and every new book in physics, including research journals. By the time he was 18 years old, his research papers were already published in the Indian Journal of Physics. One of them even appeared in the Royal Society, a rare honour for a young physicist.

In July 1930, Chandrasekhar was awarded a Government of India scholarship to pursue graduate studies at the University of Cambridge, where he became a research student of Professor R. H. Fowler. In 1933, he was awarded his Ph.D degree at Cambridge, and the following October, he was elected to a Prize Fellowship at Trinity College for the period 1933-37. Sir Arthur Eddington and Professor E. A. Milne were his friends. He met Professor Niels Bohr during his stint at the Institute for Teoretisk Fysik in Copenhagen.

On 11th September, 1936, he married Lalitha Doraiswamy who was his fellow student in Physics at Presidency College. In his autobiography, Chandrasekhar wrote:

"Lalitha's patient understanding, support and encouragement have been the central facts of my life."

Even before he reached USA, his reputation as a promising Astrophysicist reached its shores. An eminent Astronomer and Director of Yerkes Observatory, Otto Struve, offered him a job at the University of Chicago. In January 1937, Chandrasekhar joined the University of Chicago faculty as Assistant Professor and remained at the University for his entire career henceforth.

During World War II, Chandrasekhar was at the Ballistic Research Laboratories in Maryland. He was elected a Fellow of the Royal Society in 1944. In 1946, Princeton offered him the position of Henry Norris Russell, who had retired. They offered him double salary of what Chandrasekhar was getting at Chicago. In return, Hutchins, the Chancellor at Chicago University made an offer to give him double the salary that was offered to him by Princeton. However Hutchins mentioned that if Princeton was a better place for research, then he would not persuade Chandra to stay at Chicago. Chandra replied that he did not think so. Chandra rejected the Princeton offer and Hutchins often

remarked that one of his major accomplishments as Chancellor was acquiring Chandra for the University of Chicago.

Royal Astronomical Society awarded him a Gold Medal in 1953. He was elected to the National Academy of Sciences in 1955. He was awarded the National Medal of Science by President Lyndon Johnson in 1967. He received Henry Draper Medal in 1971. Royal Society awarded him the Bruce Medal in 1952 and presented him with its highest honour, Copley Medal in 1984.

Chandrasekhar was a rare combination of a physicist, an astrophysicist and an applied mathematician. Chandra also developed theories on star atmospheres, black holes, star structures and star mass. He studied stellar structure, including the theory of white dwarfs, stellar dynamics, the theory of radioactive transfer and the quantum theory of the negative ion of hydrogen, the mathematical theory of black holes and the theory of colliding gravitational waves.

Chandra was awarded a Nobel Prize in Physics by King Carl Gustav in 1983 in recognition of his work done fifty years ago, on the physical processes involved in the structure and evolution of stars.

Chandrasekhar is best known for 'Chandrasekhar's limit', which he calculated while sailing on a ship from India to Cambridge, England. It showed that stars more massive than the sun (greater than 1.44 solar masses) would explode or form black holes as they died. If this highly dense variety of star, known as the White Dwarf, has mass in excess of the limit, it explodes like thousands of nuclear bombs ignited together to become a very bright star, called Supernova, until all the excess matter is shed into space. Although Chandrasekhar calculated his 'limit' purely on mathematical equations, astronomers have found that all the White Dwarf stars in the sky have masses within his prescribed limit. When Chandrasekhar first proposed his ideas, many of the contemporary scientists, including Arthur Eddington opposed the idea.

Chandra published ten books and served as the editor of the prominent Astrophysical Journal for nineteen years. Chandrasekhar worked on the book 'Newton's Principia for the Common Reader' published in 1995.

Over fifty years of his stay in America did not turn him to take to western ways as he could be seen in his house wearing the south Indian dhoti and listening to Carnatic music. Subrahmanyan Chandrasekhar died of heart failure in Chicago on 21st August, 1995.

In the Biographical Memoirs of the Fellows of the Royal Society of London, R. J. Tayler wrote:

"Chandrasekhar was a classical applied mathematician, the likes of whom will probably never be seen again."

Great men are seldom born. All great men are self-made.

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SHANTI SWARUP BHATNAGAR

(1894 - 1955 A.D.)

MAGNETO-CHEMISTRY

Attock Oil Company was struck with a peculiar problem while drilling at Rawalpindi. The problem was peculiar as the mud used for drilling operations got solidified on contact with the saline water. This brought the drilling operations to a grinding halt. They contacted many and finally an Indian scientist managed to solve the problem.

The solution was ingenious - Indian gum.

M/s Steel Brothers, the parent company of Attock Oil Company were so happy with the results, that they offered a sum of Rs. 1,50,000/- to the scientist. The selfless scientist requested them that the amount be passed on to Punjab University to improve their research facilities. Later the Company increased the amount and extended the period from five years to ten years after the researches undertaken were found to be more fruitful.

The problem solver was Indian scientist, Shanti Swarup Bhatnagar.

Bhatnagar was born on 21st February 1894 at Bhera, (now in Pakistan) to Parmeshwari Sahai Bhatnagar, and Parbati Bhatnagar

He lost his father when he was only eight months old. His childhood was fostered in a healthy, cultural and scientific atmosphere of his maternal grandparents, where he developed a natural liking for arts, science and engineering.

Bhatnagar studied in A.V. High school in Sikandarabad and Dayal Singh High School at Lahore. Bhatnagar passed the Matriculation Examination in the first division and secured a University scholarship and yet another first division from Dayal Singh College in the Intermediate Examination in 1913. Mr. Welinker, Principal of Dayal Singh College wrote:

"Mr. Shanti Swarup Bhatnagar is a young man of more than usual ability. I am sure, he will do some remarkable work in science and will thus be in a position to render high service to his country."

His one-act play in Urdu, 'Karamati' won the first prize in a competition in his college days.

He joined the Forman Christian College in 1916 as a Demonstrator from where he passed his bachelor's degree. Later he shifted to a Senior Demonstrator position in the Dayal Singh College. In 1919, he received his M. Sc degree from the Forman Christian College. He was awarded a scholarship by the Dayal Singh College Trust for his studies abroad. He wanted to go to America via England. Unable to board a ship sailing to America, he settled for his studies at the University College of London. In 1921, Bhatnagar received the D. Sc. degree under able guidance of Professor Donnan for his thesis entitled 'Solubilities of bi and trivalent salts of higher fatty acids in oils and their effect on surface tension of oils'. He even received a Fellowship of 250 pounds a year from the DSIR, England.

In August 1921, he joined the Benaras Hindu University (BHU) as Professor of Chemistry, where he will continue to be remembered till this University exists. The University song 'Kulgeet' was written by him. Bhatnagar was appointed as Professor of Physical Chemistry, Punjab University in Lahore and

Director of University, Chemical Laboratories where he spent 16 years. After extensive researches in Magneto Chemistry, a sensitive instrument for measuring magnetic properties called 'Bhatnagar-Mathur Magnetic Interference Balance' was invented by him jointly with K.N. Mathur. It was marketed by a British firm and the Royal Society displayed a model.

He solved various Chemical Engineering problems for Delhi Cloth Mills; J.K. Mills Ltd., Kanpur; Ganesh Flour Mills Ltd., Layallapur; Tata Oil Mills Ltd., Bombay; Steel Brothers & Co. Ltd., London, etc. Bhatnagar developed a process for making food cake for cattle from sugarcane bagasse. Similarly he built up methods for deodorisation of waxes, better flame from kerosene and utilisation of waste products in vegetable oil and mineral oil industries.

Macmillan India published his book which was co-authored with K.N. Mathur titled 'Physical Principles and Applications of Magneto Chemistry'. Prafulla Chandra Ray was all praise for this book as it was adopted by foreign universities.

When Board of Scientific and Industrial Research (BSIR) was constituted on 1st April, 1940, Bhatnagar, was put in charge. In 1936, the British Government conferred him the Order of British Empire (OBE) and Bhatnagar was knighted in 1941. He was elected as Honorary Member of the Society of Chemical Industry, London in 1943 and later as its Vice President. Royal Society elected him as its Fellow in 1943. He presided over the Indian Chemical Society, National Institute of Sciences of India and the Indian National Science Congress. He was awarded Padma Vibhushan.

He was instrumental in schemes for construction of oil refineries. He conducted surveys for atomic minerals and petroleum deposits. Production of exotic metals like titanium and zirconium was encouraged by him. Bhatnagar established twelve national laboratories. Pandit Jawaharlal Nehru said:

"I can truly say that but for Dr. Bhatnagar you could not have seen today the chain of national laboratories"

He was the Secretary, Ministry of Education, Educational Adviser to Government and the first Chairman of the University Grants Commission (UGC). National Research Development Corporation (NRDC) of India and Industrial Research Association were the result of his efforts. Bhatnagar was the Founder Director of the Council of Scientific and Industrial Research (CSIR). CSIR awards every year the 'Shanti Swarup Bhatnagar Prize for Science and Technology' to outstanding scientists in the fields of Science, Engineering and Technology.

The man who breathed life into scientific research and industrial innovation in India breathed his last on 1st January, 1955.

Shanti Swarup Bhatnagar spent his childhood in the house of his maternal grandfather who was an engineer. From him, he developed a liking for science and engineering. He used to enjoy building mechanical toys, electronic batteries, string telephones and other such things.

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SIGMUND FREUD

(1856 - 1939 A.D.)

FATHER OF PSYCHOANALYSIS

When the Nazis took over Austria in March 1938, the father of psychoanalysis was in his early eighties. The threats from Gestapo were increasing and his books were being burnt in Germany. Though initially he was reluctant to move out, he was determined to die in freedom. He exiled to England with his wife and his favourite daughter and colleague Anna. Nazis started World War II by invading Poland. When German propaganda war broadcast claimed this to be the last war; Freud commented ironically:

"My last war!"

He died in freedom a year later.

Sigmund Freud was born on 6th May, 1856 into a Jewish family in Pribor in the Czech Republic. His father Jakob was a wool merchant, and his mother Amalie was a housewife. The family moved first to Leipzig, Germany and then to Vienna. Freud was an outstanding pupil and matriculated in 1873. Freud joined Medicine at University of Vienna. In 1879, Freud finished his one year of obligatory military service, and in 1881 he received his M.D.

Freud married Martha Bernays in 1886. However, from the age of forty until his death, Freud was an absolute celibate in order to sublimate the libido for creative purposes.

After starting his medical practice, he specialised in neurology. He asked his patients to talk about their problems, which came to be known as the 'Talking Cure' which is now widely seen as the basis of psychoanalysis.

His book 'The Interpretation of Dreams', was an indescribable masterpiece — a combination of dream analysis, theory of the mind, history of contemporary Vienna and his own autobiography.

University of Vienna certified him in both Neurology and Psychiatry fields. Freud was an avid researcher in Neurophysiology, specifically cerebral palsy. He published several medical papers on the topic. In 1930, Freud received the Goethe Prize for his contributions to Psychology and German literary culture. When in March 1938, Nazi Germany annexed Austria, Freud exiled to London to die in freedom.

He was an inquisitive explorer rather than a dedicated healer. He developed theories on the organisation and operation of the human mind and certain clinical techniques in Psychopathology. He said:

"The mind is like an iceberg, it floats with one-seventh of its bulk above water."

The term 'psychoanalysis' was first used by him in 1896, when he was 40. He theorised that neuroses occured from childhood experiences and repressed sexual desires and that the symptoms of hysterical patients represent forgotten and unresolved infantile psychosexual conflicts.

Freud's major contributions to western thought were unconscious mind and the interpretation of dreams. He called the dreams as royal road to the unconscious. He remarked:

"Dreams are often most profound when they seem the most crazy."

He developed the concept of the Ego, Super-ego, and Id. He said:

"The ego is not master in its own house."

He has been highly influential with his works like the Oedipus complex, defense mechanisms, Freudian slips etc.

Freud was an early champion of both sexual freedom and education for women. He said:

"Men are more moral than they think and far more immoral than they can imagine."

However his distracters like, H. J. Eysenck claimed that Freud set Psychiatry back one hundred years, consistently misdiagnosed his patients, fraudulently misrepresented case histories and that what is true in Freud is not new and what is new in Freud is not true.

A heavy cigar smoker, Freud had to undergo thirty operations during his life due to mouth cancer. It was said that he requested his doctor friend, Schur to assist him in suicide, as his health, according to him was a sheer torture:

"Now it is nothing but torture and makes no sense any more."

With heavy doses of morphine, Freud died on 23rd September, 1939 at the age of 83 in London.

Freud often received patients from abroad for treatment or advice. Naturally, these patients were wealthy and they must be paying Freud well too. So thought the Austrian tax authorities and they sent a demand notice to Freud for accounts of his earnings and expenditure. When Freud received the letter, he smiled and remarked, "At last, the official recognition of my work!"

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SUSHRUTA
(400 B.C.)

FIRST COSMETIC SURGEON

In the pitch darkness around, there was but one oil lamp flickering in a distant hut. Cries of young girl in pain suddenly filled the midnight air as two people carried her and knocked the door.

"Who's there?" asked the aged inmate opening the door.

"Save my daughter from dying!" cried one of the men.

The sage had a closer look at the girl in the light of oil-fired torch. Her leg was almost severed and blood was flowing down.

"Come on in! Don't cry! You will be alright soon!" he consoled the poor girl, taking them into neat and clean room. A number of surgical instruments adorned the walls. He made her lie on a mattress. He could see her crying in deep anguish.

He cleaned the injury with a piece of cloth, washed it with herbal juices which he extracted from the plants in his garden. Her cries were reaching skies. Consoling her, he gave her a mug of wine. He picked up appropriate instruments from the wall and prepared for the surgery.

He asked her name. She moaned in an extremely feeble voice. That confirmed, the wine worked on her as anesthesia.

He removed the broken piece of leg and applied more herbal juices, oils and ointments on the amputated leg. As blood stopped flowing, he deftly bandaged the wound and put her to sleep.

He told her father to leave her there for a few days for post-operative care. They cried seeing her amputated leg. The sage consoled them while measuring the size of her other leg, "Don't cry! She will walk again!"

Soon the girl found an iron leg crafted and kept for her. He fixed it, patted on her back and asked, "Walk! My girl, walk!"

For a moment the girl was wonderstruck and then she proudly walked with her iron leg-prosthesis.

Now it is our turn to get wonderstruck. The scene was in around 400 B.C. and the sage was one of the greatest Indian surgeons, Sushruta.

Sushruta is the descendent of sage Vishvamitra. He studied Ayurveda specialising in surgery under Divodasa and Kashira Dhanvantari on the banks of River Ganga. His exact age has never been determined exactly as is the case with most ancient Indian sages and scientists. The dates range from the 4th century A.D to 400 B.C. But surely Sushruta's contributions to medicine predates western world by half a millennium or more.

His years of tutelage under his preceptor Dhanvantari, his experience on human anatomy, his inventive genius and his intuitive knowledge places him on the highest pedestal in the medical discipline. All these superb qualities poured into the making of the Sushruta Samhita, one of the most invaluable treatises in Indian medical literature. No wonder, it was translated into Arabic as Kitab-Shaw, Shoon-a-Hindi and Kitab-i-Sushrud in the eighth century A.D.

Sushruta Samhita is in two parts, the Purva-tantra and the Uttara-tantra. It has chapters on Medicine, Pediatrics, Geriatrics,

Toxicology, Aphrodisiacs and Psychiatry, pathology, Anatomy, Midwifery, Biology and also Ophthalmology hygiene. It contains essentials of Embryology, Obstetrics and Human Anatomy. It contains instructions for cutting of veins, cauterisation by chemicals or heat. Thus the whole Samhita is one comprehensive authority on the entire medical discipline.

In the ancient medicine (Ayurveda), surgery was considered the first and foremost branch. Sushruta is considered the father of Indian surgery. Spreading over 300 surgical procedures, classified into 8 categories, he describes management of variety of surgical conditions, including the very first descriptions of several operations, such as the obstetrical emergencies and even removal of the prostate gland. Fourteen types of bandaging were used by him. Urinary stones, extraction and operating problems are described in detail. Sushruta Samhita has 18 chapters on eye with 76 different diseases and 51 operations including varieties of cataracts. Sushruta was a forerunner of antisepsis and anaesthesia for which he used and advised wine. He gives full directions for post-operative care. It will be interesting to note that he gave out the methods of fracture treatment, such as traction, manipulation, appositions, stabilisation and rehabilitation.

His method of nasal repair or rhinoplasty is still practiced to this day. He is the 'Father of Plastic Surgery' who narrated the fundamental principles of plastic surgery. Only after the advent of East India Company, British physicians learnt Rhinoplasty from Indian counterparts. Sushruta made and used 101 blunt instruments and 20 sharp instruments, some of which have an edge so fine that it would divide the hairs on the skin. He named surgical tools after the animals or birds they resemble in shape.

Sushruta describes about 1120 diseases of the ear, nose, throat, eye and the head. He also describes different types of fever, dysentery, cough, hiccough, pulmonary tuberculosis; leprosy; diabetes and urinary diseases; liver cirrhosis and even

treatment of a number of poisons. About 760 herbal drugs were described. His diagnostic procedures like questioning and clinical examination with all five senses, pulse and urine study were methods followed a thousand years before the western world.

He made it clear that the hand is the most important and versatile instrument and explained that surgical skill can only be acquired by careful study, practical observation and continual practice. He cautioned:

"Without practice, you are like a one-winged bird that is incapable of flight."

He actually developed and made use of (in the modern concept) training modules and workshops in surgical procedures, post-operative care and disease management. He also warned that a meticulous surgeon should consider the patient as a whole.

Sushruta opined that good health is a pleasant harmony of the body and the mind achieved by good nutrition, proper elimination of waste products and there can be nothing more magnificent than the act of removing human suffering.

Sushruta was also a notable teacher. He told his pupils that one could become a good physician only if one knew both theory and practice. He advised his pupils to use carcasses and models for practice before surgery.

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ALBERT SZENT-GYORGYI

(1893 - 1986 A.D.)

VITAMIN C

His studies were disrupted as he was drafted into the war in 1914. He won the silver medal for valour but by 1916 he was disgusted with the war. He shot himself in the arm, claimed injury from enemy fire, and was back home on medical grounds. He fulfilled his ambition and received his M.D. in 1917. That was during World War I.

During World War II, Adolf Hitler himself issued an arrest warrant for him as he was actively participating in the Hungarian Resistance Movement. He escaped house arrest and spent 1944 to 1945 as a fugitive from the Gestapo. He received extensive help from the Swedish Embassy in Budapest.

He was awarded the Nobel Prize in Physiology in 1937 for his discoveries in connection with the biological combustion process with special reference to vitamin C and the catalysis of fumaric acid. For him, Research was not a systematic occupation but an intuitive artistic vocation.

That was Albert von Szent-Gyorgyi born in Budapest on 16th September, 1893 to Nicolaus and Josefine. After his matriculation in 1911, he hoped to study a two-year course in Physical

Chemistry at the Institute for Tropical Hygiene, Hamburg, but could not because of the war. He married Kornélia Demény, the daughter of the Hungarian Postmaster General in 1917.

In 1920, he joined the University Institute of Pharmocology in Leiden as an assistant and from 1922 to 1926 he was at the Physiology Institute, Groningen, Netherlands. His researches in the Chemistry of Cellular Respiration earned him a Rockefeller Foundation fellowship at Cambridge University. He received his Ph.D from Cambridge in 1927 for his work on isolating what he then called 'hexuronic acid' (now known as vitamin C) from adrenal gland tissue.

He accepted a position at the University of Szeged in 1931. He continued his researches and by 1938, he developed fundamental theories in muscle contraction which became the basis of muscle research later.

Szent-Gyorgyi became Head of the Biochemistry department at the University of Budapest where he established a lab. His extreme sensibility to human issues brought him to politics and he was elected as a Member of Parliament. He was the President of the Academy of Sciences and Vice-President of the National Academy, Budapest.

He was a visiting Professor at Harvard University in 1936 and Franchi Professor at University of Liège, 1938. Cameron Prize (Edinburgh) was awarded to him in 1946. He emigrated to the United States in 1947 and established a lab at the Marine Biological Laboratory in Woods Hole, Massachusetts. In 1948, he received an additional research position with the National Institute of Health (NIH) in Bethesda, Maryland. In 1950, he established the Institute for Muscle Research with funding from the Armour Meat Company and the American Heart Association.

He often said:

"Discovery consists of seeing what everybody has seen and thinking what nobody has thought."

No wonder he received the Albert Lasker Award for basic medical research in 1954. He became a member of the National Academy of Sciences in 1956.

He worked all his life so that human life could be made enjoyable by health, happiness, beauty and knowledge. But Szent-Gyorgyi lost both his wife and daughter due to cancer. His research interests turned to cancer and he applied the theories of Quantum Physics to the Biochemistry of cancer, visualising an electronic problem at the molecular level. His researches pointed to the free radicals as a cause of cancer. Franklin Salisbury helped him to establish a private non-profit organisation, the National Foundation for Cancer Research.

Some of his publications are – 'Oxidation, Fermentation, Vitamins, Health and Disease' (1939); Muscular Contraction (1947)'; 'The Nature of Life' (1947); 'Contraction in Body and Heart Muscle' (1953); and 'Bioenergetics' (1957).

He died in Woods Hole, Massachusetts on 22nd October, 1986.

His discovery needed a name and it had to end with '.....ose' like all sugars (as in sucrose, lactose, glucose). Szent-Gyorgyi suggested the name 'ignose' because then, he thought it was a sugar and its structure uncertain. The editor of the journal where his paper was to be published did not like the name and asked him to suggest a new name.

The new name : Godnose!

God really knows.

Hence the final name : Vitamin C!

□□

THEODORE H. MAIMAN

(1927 - 2007 A.D.)

PRACTICAL LASER

On 7th July, 1960, Hughes held a press conference to announce the invention of the Laser. A number of future applications for the laser like cutting, welding, communications, medical uses were explained.

A reporter questioned about use of the laser in making weapons.

The scientist told him, "I didn't think it very likely."

He persisted, "Will you deny that the laser could be used that way."

"No!"

The next day newspapers screamed: "L.A. man discovers science-fiction death ray."

Laser has now invaded into our lives with its uses in education to entertainment, medicine to communication. Not a death ray, but it is used extensively in scientific research and military and industrial applications.

That L.A. man was Theodore Harold Maiman, born in Los Angeles, California, on 11th July, 1927. His father had deep interest in experimental Physics, particularly Electronics. He was

working on Medical Electronics much before anybody thought of it and encouraged his son to do so. Young Maiman imbibed the qualities of his father. By his twelfth year he was repairing valve radios and by fourteen, he was running a shop.

He received a bachelor's degree in Engineering Physics in 1949 from the University of Colorado and M.S. in Electrical Engineering in 1951 from Stanford University. Working under Nobel Laureate Willis Lamb at Stanford, he obtained Ph.D in Physics in 1955. His experience and experimentation on optical instrumentation paved the road for his later efforts on the laser.

In 1958, Prof. Schawlow and Prof. Townes predicted the possibility of an optical laser. They were even granted a patent. But a working laser had its difficulties. By 1960, the race for building an optical laser reached a feverish pitch with most of the giants like Bell Labs, RCA Labs, TRG, Lincoln Labs, IBM, Westinghouse, Siemens and GE, vying with each other but without success. Many scientists even became pessimistic of the likelihood of a LASER (Light Amplification by Stimulated Emission of Radiation).

Maiman, who was by now at Hughes Research Institute, worked under a plethora of problems, paltry funds, and ridicule of co-scientists. His selection of ruby as the lasing material was discouraged by the studies made by his own protege Irwin Weider. Keeping conventional wisdom aside he made fresh studies. He returned wiser, back to the ruby as the right material. He ordered an optically finished ruby rod from Union Carbide, which took about six months to make and supply. He resorted to a special technique developed earlier by him to silver its ends. For the light, he zeroed on strobe lamps used by photographers with brightness temperature of about 8000 or 9000 K and found an ingenious way of making an external collector.

On 16th May, 1960, after nine months of effort, the world's first laser became a reality.

Scientific community was, however, difficult to appease. Physical Review Letters rejected a paper submitted to it on the subject. 'Nature' from UK published a very short article named 'Stimulated optical radiation in ruby' on 6th August, 1960.

Laser has now found its place from medicine to education, computers to communication and entertainment to artillery. Maiman's sound background of electronics and optics, coupled with unparalleled perseverance and undaunted confidence resulted in Laser, the great life saving device. He avoided what he called, the 'guru effect'. It is the blind following of advices of the mentors often leading researches off their course.

After leaving Hughes, Maiman joined Quantatron looking after its Laser facilities. But later, Union Carbide bought these laser facilities. In 1962, he founded his own laser research and manufacturing company, Korad. After selling Korad to Union Carbide in 1968, he established a venture capital firm called Maiman Associates in 1976, for the pleasure of what he called "working at the interfaces". He joined TRW in 1976 as Vice President of Advanced Technology. He was also the Director of Control Laser Corporation and a member of the Advisory Board of Industrial Research Magazine.

When quizzed whether he considered himself a scientist or an engineer, Maiman answered that he was both. No wonder, he was nominated as member of both the National Academies of Science and Engineering. He was twice nominated for a Nobel Prize but it eluded him. He was awarded the Japan Prize - Asia's answer to the Nobel Prize, in 1987. He received the Oliver E. Buckley Prize in 1966. He was honoured with the 1983-84 Wolf Prize in Physics and SPIE's President's Award in 1985. He was inducted into the National Inventors Hall of Fame in 1984. He authored a book titled 'The Laser Odyssey'.

Such a brilliant flame was finally extinguished on 5th May, 2007 when Maiman died from systemic mastocytosis in Vancouver, Canada.

Once he met the famous Hollywood actress, Bette Davis in an evening party. She asked him if he had regretted about inventing the 'death ray'. Far from regretting, he told her that he had fulfilled his father's dream of bringing electronics to medicine. From the abundant uses laser has now in everyday medicine, it is a ray of life rather than a death ray.

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TIM BERNERS-LEE

(1955 A.D....)

INTERNET

His parents taught him to use Mathematics everywhere, even at the dining table. By habit, he played with imaginary numbers even while eating. By hobby, he built a computer with TTL gates and M6800 processor and an old television while still at the Queen's College at the Oxford University, England, where he graduated in 1976 with a degree in Physics.

He felt that Physics was fun and a good preparation for creating a global system. A Victorian encyclopedia book named, 'Enquire Within Upon Everything' fascinated him in his childhood. Later he did create a global system, and he called it by that name.

Now log on to Internet, start any search engine such as Google or Yahoo and type in for any thing. Information explodes in front of you in rolls of pages. The man behind this information explosion is Tim Berners-Lee. He created the World Wide Web single handedly.

Tim Berners-Lee was born in London on 8th June, 1955. His parents, Conway Berners-Lee and Mary Lee Woods were mathematicians.

After graduation, while at Plessey Telecommunications Ltd. and D.G Nash Ltd., he worked on typesetting software and multitasking. In the later half of 1980, he was a consulting software engineer at CERN, the European Particle Physics Laboratory in Geneva, Switzerland.

In those days at CERN and at The Swiss Alps, he conceptualised the idea for the future World Wide Web. He called it 'Enquire'. This program formed the conceptual basis for the future development of the World Wide Web to keep track of all the random associations one comes across in real life.

After a stint at John Poole's Image Computer Systems Ltd., he returned to CERN. He submitted a proposal in 1989 to link the computers worldwide allowing users to surf around and access information. Ironically he did not receive a reply.

But he wrote the main language of the web, HTML (Hypertext Mark-up Language) and then made set of rules called HTTP (Hypertext Transfer Protocol) to link documents on computers across the Internet. He devised a way to write the addresses with a Universal Resource Identifier (URI), now known as Uniform Resource Locator (URL). www or World Wide Web was unveiled in 1991. NeXTcube at CERN became the first web server and the world is no longer the same again.

Eric Schmidt, CEO of Novell commented in the New York Times:

"If this were a traditional science, Berners-Lee would win a Nobel Prize. What he's done is that significant."

As he refined his ideas of URI, HTTP and HTML with the feedback from larger circles, Lee founded World Wide Web Consortium W3C in 1994 at the Massachusetts Institute of Technology comprising of various companies to standardise, revolutionise and improve the Web, a free independent body, without the hassles of any Government or Corporation. He is the author of the book 'Weaving the Web'.

Unlike other software giants, who lead the Forbes List, he allowed his ideas to be used freely. He made no patents and claimed no royalties. But awards and recognition poured in.

The University of Southampton, first to recognise Tim's potential, presented him with an honorary degree in 1996.

In 1997, he was made an officer in the Order of British Empire.

He became the Fellow of Royal Society in 2001.

He received a prize from Japan in 2002.

He became the first recipient of Finland's Millennium Technology Prize worth one million euros, on 15th April 2005.

Royal society of Arts honoured him as its Fellow in May 2006.

He was ranked as the 'Knight Commander' by Queen Elizabeth on 16th July, 2004. It is the second highest rank in the Order of British Empire.

On 13th June, 2007, he received 'Order Of Merit' as personal gift from the Queen.

Time Magazine rated him among the 100 people who influenced the 20th century.

Tim Berners-Lee now lives in Lexington, Massachusetts, USA with his wife and two children.

They may call it a home page, but it is more like the gnome in somebody's front yard than the home itself.

His comment on Internet home pages.

□□

M. K. VAINU BAPPU

(1927 - 1982 A.D.)

ASTRONOMER

At the Kavalur Observatory, in Kavalur, Tamil Nadu, a telescope of 2.3-meter aperture was commissioned with totally indigenous technology. A very high resolution telescope, it could easily resolve a 25 paise coin kept forty kilometers away. On 6th January, 1986, the day of its inauguration, the observatory was named as Vainu Bappu Observatory and telescope as Vainu Bappu Telescope. Unfortunately, the brain behind the observatory could not really see the skies through this telescope as he passed away before its completion.

The Astronomical Society of India has constituted a fund in honour and memory of Professor M.K. Vainu Bappu to promote knowledge of Astronomy and Astrophysics and honour the contributions made by young scientists, from any part of the world, in the fields of Astronomy and Astrophysics.

Who was this Vainu Bappu?

An Astronomer par excellence! Within a few months of his joining Harvard for his Ph.D, he discovered a comet. This comet was named Bappu-Bok-Newkirk comet. Computation of the orbit ahead of experienced professionals placed Bappu high above others. Donhoe Comet-Medal by the Astronomical

Society of the Pacific was awarded to him in 1949 for this achievement. While working at the Hale Observatories as Carnegie Fellow, he jointly discovered an important phenomenon in stellar chromospheres, the Wilson-Bappu Effect. Needless to say, he is one of the greatest Indian astronomers in modern times.

Manali Kallat Vainu Bappu was born on 10th August, 1927. His father was Sunanna Bappu, a senior astronomer in the Nizamiah Observatory, Hyderabad and mother was Manali Kukuzhi. He was brought up in an environment of astronomy and stellar observations. He was a star performer in the studies and brilliant in extra-curricular activities. No wonder even at a young age, he published papers on star observations. First one was published in 1946 in the volume 15 of 'Current Science.'

He received his Masters degree in Physics from Madras University and moved to the Harvard School of Astronomy. With a Ph.D from Harvard on hand, in 1952 he joined the Palomar observatory on the prestigious Carnegie Fellowship. There, he discovered the Bappu-Wilson effect along with Colin Wilson. It is used to determine the luminosity, distance and some of their spectral characteristics of certain stars.

Dr. Vainu Bappu returned to India in 1953. He became instrumental in the revitalisation of Optical Astronomy in independent India. In November 1954, he had to take over the reins of the Uttar Pradesh State Observatory (UPSO) as Chief Astronomer, the senior most position. He brought the institute to the topmost position both strategically and scientifically by building the observatory at the present location at Manora Peak, Nainital.

Soon after joining the Kodaikanal Observatory in 1960 as the Director, M.K. Vainu Bappu realised that it is not the right place for making stellar observations. A vigorous search brought him to a sleepy village called Kavalur in the Javadu Hills, in

Tamilnadu. He built the Kavalur Observatory there from the scratch with unmatched initiative, vision, and dynamism.

With an unrivaled determination and dedication, he established The Indian Institute of Astrophysics. He was an Honorary Foreign Fellow of the Belgium Academy of Sciences and Honorary Member of the American Astronomical Society. He presided over the International Astronomical Union in 1979.

He developed complications arising after a heart surgery while on assignment in Munich. Vainu reached near the stars up in the other heavens on 19th August, 1982, before he could watch the heavenly skies of this Universe through his own telescope at Kavalur.

Vainu Bappu was born in a Thiyya family from the state of Kerala. Bappu senior was an astronomer and young Vainu inherited from his father a deep fascination for observing the wide and mysterious cosmos.

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VARAHAMIHIRA

(499 - 587 A.D.)

MATHEMATICIAN AND ASTROLOGER

King Vikramaditya II was seated on a high throne and the assembly was filled with ministers, poets, astronomers and astrologers in their respective thrones. But the mood was solemn. The queen was in a state of shock.

Breaking the silence, the king asked one more time, "Is it true?"

Royal astrologer stood up, speaking, "True, my Lord, however bitter it may be! I checked and rechecked planetary positions. The prince is destined to die at the age of eighteen." His voice was firm.

Recovering from her emotions, the queen asked him to find any solutions or countermeasures like mantras, special prayers, worships to save her son. The astrologer shook his head in negation.

Queen begged the king, "O emperor of the Earth! Can't you save my son?"

Vikramaditya took every precaution to save his son. But can we beat providence? On the ill-fated day, a boar killed the prince.

Vikramaditya Chandragupta II summoned Mihira. "I am defeated. I thought that I could intercede the divine will. You have won!"

The astrologer said, "My Lord, I am equally sad. I never wished to win over the great emperor. It is the victory of science. Astronomy and Astrology are sciences."

Then the king conferred on him the Magadha kingdom's greatest award, the title of the Varaha (boar) for his mastery of the great science of astrology. He inducted him to the august gathering of great men in his court, Navaratna, the Nine Gems.

Varahamihira was born in 499 AD at Kapittha, a village near Ujjain. His father Adityadasa, as the name suggests, was a worshipper of the Sun God and he taught his son Astrology. Mihira's lifetime quest for Astrology and Astronomy began after a meeting with the great astronomer and mathematician, Aryabhatta at Kusumapura (presently Patna.) Settling at Ujjain, then the center of learning, he soon became proficient in Vedas. His command over Sanskrit enabled him to embellish his articles in all the poetical finesse of that classical language.

He was a scientist in its true sense and not a blind believer. He was the first to declare that some 'force' keeps bodies stuck to the Earth. This force is now known as 'Gravity'. He confirmed that the Earth was spherical but could not understand that it was in motion. His contributions to ecology, hydrology and geology are immense. His observation of plants and termites as valid indicators of underground water is now widely accepted. He made studies on earthquakes and sought to predict them with the abnormal activity of animals, underground water and under-sea conditions, unusual cloud behavior and cosmic and planetary references. It is in that direction that scientists are now looking into in the prediction of earthquakes.

The 32nd chapter of Brihat Samhita contains 'Signs of Earthquake'. It discusses the descriptions of heavenly bodies, their movements and conjunctions, meteorological phenomena, indications of the omens these movements, conjunctions and phenomena represent, what action to take and operations to accomplish, sign to look for in humans, animals, precious stones, etc.

Varahamihira made certain important mathematical discoveries including some trigonometric formulae. His improved methods and accuracy helped other Indian astronomers later in their applications.

He was a prolific writer who wrote three important books – Pancha Siddhantika, Brihat Samhita, and Brihat Jataka. These are considered as some of the authoritative texts on ancient Indian Astronomy and Astrology.

Pancha Siddhantika (the Five Astronomical Canons) was written around 575 A.D. which summarises early astronomical systems such as Surya Siddhanta, Romaka Siddhanta, Paulisa Siddhanta, Vasishtha Siddhanta and Paitamaha Siddhanta. It renders an insight into the ancient history of Hindu Astronomy. The 11th century Arabian scholar Al-Biruni described it as:

"They (the Indians) have 5 Siddhāntas:

- Sūrya Siddhānta, ie. the Siddhānta of the Sun, composed by Lāma.
- Vasishtha Siddhanta, composed by Vishnu Chandra.
- Paulisa Siddhānta composed by Paulus Alexandrinus from Roman Empire.
- Romaka Siddhānta, from the Roman Empire, composed by ŪrîsheGa.
- Brahma Siddhānta, composed by Brahmagupta."

Brihat Samhita (the Great Compilation) is a compendium of a number of topics and beliefs prevalent those days.

Brihat Jataka is an invaluable treatise on Hindu Astrology and Horoscopy. In this book Varahmihira wrote:

"The science of astrology is a vast ocean and is not easy for everyone to cross it. My treatises provide a safe boat."

Mihira traveled far and wide, even as far as Greece. His works show the influences of his travels and foreign knowledge. He died in 587 A.D.

Indian Parliament honoured this great mathematician by placing a mural painting of Varahamihira in the Parliament House. □□

VIKRAM SARABHAI

(1919 - 1971 A.D.)

SPACE SCIENTIST

He could have followed the family tradition and become an industrialist and got listed in the Forbes. He could have stayed in any one of the foreign universities and got himself a Nobel. But here is a scientist who devoted his life to the betterment of science and technology in the country, to the development in the country and indirectly making millions of Indians to reach unheard of education levels.

As number of Indian satellites now hover over the space, bringing technology, communication, agriculture, environment, education and entertainment to our doorsteps, there smiles one man invisibly in much higher and unknown lands.

When Aryabhatta-I was launched in 1975 from a Russian Cosmodrome, it was just another tiny little sphere in the vast space. At that time, nobody imagined that it would harbinger a revolution in the fields of communication, weather, education and entertainment in the years to come.

A rare amalgamation of an innovator, technocrat and visionary, Vikram Sarabhai was born on 12th August, 1919 in Ahmedabad with a silver spoon in his mouth. His parents Ambalal and Sarla Devi were affluent industrialists. His early

education was in Retreat School, a school managed by his parents on Montessori lines, which imparted a spirit of scientific temperament and visionary zeal in the young mind. After matriculation from Gujarat College in Ahmedabad, he joined St. John's College, University of Cambridge. He received the Tripos in Natural Sciences from Cambridge in 1940. He returned home due to World War II and served as a research scholar at the Indian Institute of Science under the Nobel Laureate, Sir C. V. Raman.

After doing cosmic studies at Bangalore and Pune, he ventured to Himalayas in 1943 with a view to study them at high altitudes. He was only 23 then. Cosmic rays are a stream of energy particles coming to the Earth from outer space. He set up a laboratory there to study cosmic rays, his first love.

In September 1942, Vikram Sarabhai married Mrinalini, a Bharatanatyam dancer of international repute. Their daughter Mallika is again a famous dancer, and son Kartikeya returned to the roots of family industry. Back to Cambridge in 1945, Vikram received his Ph.D degree for his thesis titled 'Cosmic Ray investigation in Tropical Latitudes', in 1947.

Sarabhai established The Physical Research Laboratory (PRL) on 11th November, 1947 in M.G. Science Institute of the Ahmedabad Education Society for the study of cosmic rays. Later, he opened its branches at Kodaikanal in 1951 and Gulmarg in Kashmir, and Trivandrum in 1955. He wanted science and technology to reach the common man. He realised the traditional approaches do not really yield desired fruits and decided to harness the vast indigenous technological skill and knowledge for a revolution in the fields of communication, meteorology, remote sensing and education. We are now harvesting his vision, proving the indigenous capability of satellite technology, way ahead of other third world countries.

Emphasising the space program, he said:

"There are some who question the relevance of space activities in a developing nation. To us, there is no ambiguity of purpose.

We do not have the fantasy of competing with the economically advanced nations in the exploration of the moon or the planets or manned space-flight. But we are convinced that if we are to play a meaningful role nationally, and in the community of nations, we must be second to none in the application of advanced technologies to the real problems of man and society."

Sarabhai ushered in the space age in India when the first Rocket Launching Station (TERLS) was set up at Thumba near Thiruvananthapuram on the Arabian Coast. From this equatorial launching station, the first rocket with sodium vapour payload was launched on 21st November, 1963. Soon the Physical Research Laboratory became the Headquarters for Space activities. An Earth Station was established at Ahmedabad along with Space Science and Technology Center at Thumba. Sarabhai became Chairman of the Indian National Committee for Space Research.

Sarabhai received Bhatnagar Medal in 1962, and Government of India conferred on him Padma Bhushan in 1966. After the sudden demise of Homi Bhabha in an air crash, Sarabhai was appointed as the Chairman, Atomic Energy Commission in May 1966. He presided over the Physics section of the Indian Science Congress and was the President of the General Conference of the I.A.E.A., Verina in 1970 and Vice-President of the Fourth U.N. Conference on 'Peaceful uses of Atomic Energy' in 1971.

His interests are wide and varied. He founded a Community Science Centre at Ahmedabad in 1966, now called the Vikram A. Sarabhai Community Science Centre. With the same breath, he opened a dance academy called Darpana. He was equally caring for the physically challenged. He started BMA (Blind Men Association) which lent a hand in imparting necessary skills and support to visually challenged people.

One of the prestigious and internationally renowned business schools, the Indian Institute of Management, Ahmedabad was his creation. Operations Research Group (ORG), the first market research organisation in the country was his

brain child. To help the thriving textile business at Ahmedabad, he established ATIRA (Ahmedabad Textiles Industrial Research Association). Environment was his main concern much before it became a more fashionable word and CEPT (Center for Environmental Planning and Technology) was the outcome of this concern.

The Vikram Sarabhai Space Centre, (VSSC), located in Thiruvananthapuram (Trivandrum) is named after him. The International Astronomical Union has named a 7-km diameter crater on the moon in the sea of serenity after him.

Unfortunately he was not there to see the faces of beaming villagers across 2400 villages in India watching the telecast from the Satellite Instructional Television Experiment (SITE) in 1975-76, the result of his unrelenting effort with NASA.

Vikram Sarabhai breathed his last on 31st December, 1971 at Kovalam, Thiruvananthapuram, where he was found lying on his back under a mosquito net, with a smile on his face and an open book on his chest.

Mission accomplished!

As the Sarabhai family was involved in the Indian freedom struggle, many leaders of the freedom struggle like Mahatma Gandhi, Motilal Nehru, Rabindranath Tagore and Jawaharlal Nehru used to frequent the Sarabhai house. This is said to have greatly influenced the young Vikram Sarabhai and played an important role in the shaping his personality.

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WALTER BRATTAIN
(1987 - 1902 A.D.)

TRANSISTOR

At 7 a.m. on 1st November, 1956, one of the trio who transformed the twentieth century, got a phone call from a reporter friend, that he had been awarded the Nobel Prize for an invention made in 1948. Needless to say, he was soon swamped by the media. Later, as he walked into a meeting, he received a spontaneous standing ovation. He was in tears. Humble as he was, later he wrote:

"What happened there is a matter of record, except possibly the extreme emotion that one feels on receiving the acclamation of one's colleagues and friends of years, knowing full well that one could not have accomplished the work he had done without them, and that it was really only a stroke of luck that it was he and not one of them."

That was when Bardeen, Brattain and Shockley were doing fundamental research on crystal surfaces at the Bell Labs. They were investigating into the alternatives for delicate vacuum tubes. The experimental results were not very good. William Shockley, the leader of the team almost cancelled the project. Whatever they were doing, was getting spoiled by condensation. However best they tried, condensation kept

forming on the silicon contraption. To resolve the problem, they could have evacuated the whole thing, but it would take time and the experiment was not exactly designed for the same.

And then, on 17th November, 1947, Brattain placed the experiment into a thermos of water. He and another scientist, Robert Gibney, who were looking at the experiment, were dumbfounded for a minute. To their surprise, the device started giving amplification. Did he do it in a fit of frustration? No! Walter Brattain actually thought over it. "I toyed around the idea in my mind." he said.

On 16th December, Brattain sat down for one more trial for bigger amplification. In front of him were a slab of germanium and two gold point contacts just fractions of a millimeter apart. Walter Brattain wound a ribbon of gold foil around a plastic knife, and pushed it delicately through one of the points. Straight came a fantastic effect — signal went in through one gold contact and multiplied as it rushed out of the other. He was suddenly very excited and said aloud to himself, "This thing's got gain!" And for once everything seemed to work just right.

The germanium transistor was first demonstrated privately at Bell Labs on 23rd December, 1947, by Brattain, Bardeen and Shockley. The first public announcement was made only on 30th June, 1948, only after initial production problems were solved. They called it the transistor; in a word they created from transfer and resistor. But soon, rift began between the trio, when Shockley tried to patent the transistor in his own name. Brattain shouted at him when he was trying to strike a deal:

"There's more than enough glory in this for everybody!"

Walter Brattain was the tinkerer, who could build any contraption. Walter H. Brattain was born in Amoy, China, on 10th

February, 1902, to Ross R. Brattain and Ottilie Houser, while they were in China. He received his B.S. degree from Whitman College in 1924. With the encouragement from his professor Benjamin Brown, Brattain went on to the University of Oregon for his Masters in 1926. Brattain recalled later:

"I asked Brown about going on [in Physics]. I told him that I didn't want to go on unless I could be at least better than average. In fact, I think I asked him whether he thought I had what it took to be a good physicist. I didn't want to be a mediocre one. And he assured me that he thought I was capable of being a good physicist."

For a year, he worked with the National Bureau of Standards as a radio engineer, but moved to the University of Minnesota to receive a Ph.D in 1929. On 1st August, 1929, Brattain joined Becker's Lab in New York City, studying copper-oxide rectifiers. Later he joined Bell Labs. Brattain spent the war years working on ways to detect submarines under a contract with National defense research Council at Columbia University. After war, he returned to Bell Labs to the newly organised solid state group. The rest is history.

Dr. Walter Brattain received the honorary Doctorates from Portland University in 1952, from Whitman College and Union College in 1955, and from the University of Minnesota in 1957. He was awarded the Stuart Ballantine Medal of the Franklin Institute in 1952, and in 1955 the John Scott Medal. He was a member of the National Academy of Sciences and of the Franklin Institute; a Fellow of the American Physical Society, the American Academy of Arts and Sciences, and the American Association for the Advancement of Science and also a member of the Commission on Semiconductors, part of the International Union of Pure and Applied Physics, and of the Naval Research Advisory Committee.

In 1935, he married Dr. Keren Gilmore. They had one son, William Gilmore Brattain. In 1958, he married Mrs. Emma Jane (Kirsch) Miller.

After retirement from Bell Labs, he went back to teach at Whitman College. He worked on Biophysics, taught Physics for non-science students. He died of Alzheimer's disease at the age of 85 on 13rd October, 1987.

While listening to the music being played at Whitman College grounds at full volume, thanks to his invention, he often said, "The only regret I have about inventing the transistor is, its use for rock and roll."

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WASHINGTON CARVER

(1864 - 1943 A.D.)

AGRICULTURAL SCIENTIST

Those were the tough times of American Civil War. Shortly after his birth, a boy and his mother were kidnapped. He was found by his foster parents who reared him as their own child. He was not allowed to join the nearby school due to rampant racism prevalent then. One day, he left home and walked all 16 kilometers with his only shirt and knickers to get admission to a school which would allow black students. When he reached there, to his dismay, he found that the school was closed for the day. He sat on the compound wall throughout the night for fear of missing the school next morning.

That boy invented some three hundred uncommon uses for common peanuts and hundred more uses for soybeans and sweet potatoes. In those days peanuts were not used for anything other than eating. He developed crop rotation method, which revolutionised American agriculture. He educated the farmers to alternate the soil-depleting cotton crops with soil-enriching crops such as - peanuts, peas, soybeans, sweet and potato. This was blessing for soil-depleted America, with decades of growing only cotton and tobacco. It revolutionised American agriculture from one crop blunder-land to multi-crop wonderland.

It is rare to find a man of the caliber of George Washington Carver, a man who would decline an invitation to work for a salary of more than $100,000 a year (almost a million today), instead settled to continue his researches; a man who did not patent or profiteer from most of his products. He freely gave his discoveries to mankind. He said:

"God gave them to me! How can I sell them to someone else?"

George Washington Carver was born in 1864, in Missouri, on the farm of Moses Carver. His love with nature earned him the nickname 'The Plant Doctor'.

He began his formal education at the age of twelve. As no school was available for black students near Carver's home, he moved to Newton County, where he worked as a farm hand and studied in a one-room schoolhouse. He went on to attend Minneapolis High School in Kansas. College entrance was again a struggle. He tried his hand at farming on the sandy land that government gave him, but failed. To raise money for his studies, he worked at a hotel and even sang songs at a club. He believed:

"There is no short cut to achievement. Life requires thorough preparation — veneer isn't worth anything."

In 1887, at the age of thirty, Carver gained acceptance to Simpson College in Iowa, where he was the first black student. As he was keen on science studies, he later joined the present Iowa State University in 1891. He got his Bachelor of Science degree in 1894 and a Master of Science degree in Bacterial Botany and Agriculture in 1897. In the same year, Carver was invited by Booker T. Washington, to serve as a Director of the Tuskegee Institute, where he remained until his death in 1943.

Countless products we enjoy today come to us from Carver. Some of them are - adhesives, axle grease, bleach, buttermilk, chilli sauce, fuel briquettes, ink, instant coffee, linoleum, mayonnaise, meat tenderiser, metal polish, paper, plastic,

pavement, shaving cream, shoe polish, synthetic rubber, talcum powder and wood stain. His attitude in life was:

"Learn to do common things uncommonly well; we must always keep in mind that anything that helps fill the dinner pail is valuable."

Carver also worked at developing industrial applications from agricultural crops. During World War I, he found a way to replace the textile dyes formerly imported from Europe. He produced dyes of 500 different shades. In 1927, he invented a process for producing paints and stains from soybeans. For that he received three separate patents.

Humbleness is the hallmark of a high quality scientist and Carver stands higher than most other scientists. He said:

"It is not the style of clothes one wears, neither the kind of automobile one drives, nor the amount of money one has in the bank, that counts. These mean nothing. It is simply service that measures success."

In 1940, Carver donated his life savings to the establishment of the Carver Research Foundation at Tuskegee, for continuing research in agriculture.

Carver advised the young generation:

"How far you go in life depends on your being tender with the young, compassionate with the aged, sympathetic with the striving, and tolerant of the weak and the strong. Because someday in life you will have been all of these."

George Washington Carver was bestowed an honorary doctorate from Simpson College in 1928. He was an honorary member of the Royal Society of Arts in London, England. In 1923, he received the Spingarn Medal given every year by the National Association for the Advancement of Coloured People and the Roosevelt Medal for restoring southern agriculture in 1939. He died on 5th January, 1943.

On 14th July, 1943, US President Franklin Delano Roosevelt honoured Carver with a national monument dedicated to his accomplishments. The area of Carver's childhood near Diamond

Grove, Missouri has been preserved as a park. This park was the first designated national monument to an African American in the United States.

"He could have added fortune to fame, but caring for neither, he found happiness and honour in being helpful to the world." - Epitaph on the grave of George Washington Carver.

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WILLIAM SHOCKLEY

(1910 - 1989 A.D.)

TRANSISTOR

In February 1956, William Shockley founded Shockley Semiconductor Laboratory in Palo Alto, California, heralding the beginning of Silicon Valley. One of his first employees was the future 'Intel' co-founder Gordon Moore. Moore later remarked,

"Unintentionally, Shockley contributed to one of the most spectacular and successful industry expansions in history."

Shockley received the Nobel Prize in Physics in 1956, along with Bardeen and Brattain, though he gave full credit to Brattain and Bardeen as the inventors of the Point-Contact transistor in his Nobel lecture. Time Magazine rated him as one of the 100 most influential people of the 20th century.

William Bradford Shockley was born in London. His father was a Mining Engineer and mother, a Mineral Surveyor. After early schooling in Palo Alto, California, he attended Alto Military Academy and Hollywood High School. Shockley had his bachelor's degree from Caltech (California Institute of Technology) and received Ph.D at M.I.T. for a dissertation titled 'Calculations of Wave Functions for Electrons in Sodium Chloride Crystals.'

He got his first patent, 'Electron Discharge Device' on Electron Multipliers in 1938. He was involved in radar research during World War II and the Secretary of War, Robert Patterson awarded Shockley the Medal of Merit on 17th October, 1946 in recognition of his contributions.

In 1945, he joined newly formed Solid State Physics Group at Bell Labs, with an assignment to develop alternative to the delicate valve or vacuum tube amplifiers. The month of December in the year 1947 was known as 'Miracle Month' at Bell Labs when a Point-Contact Transistor was created by Bardeen, Brattain and, of course, Shockley. The Germanium Transistor was first demonstrated privately at Bell Labs on 23rd December, 1947, by William Shockley and his team. The first public announcement was made only on 30th June 30, 1948 after initial production problems were solved. They called it the Transistor; in a word they created from transfer and resistor.

Shockley, who guided the invention team, said,

"Exploiting its potential caused many headaches. A colleague called it a persistor because persistence was what it took to make it."

Yes, it was persistence that made him to invent a better version of the transistor single-handedly. His eyes were on a junction transistor, a kind of transistor based on junctions rather than point contacts. He put forth his ideas in 'Electrons and Holes in Semiconductors', which was a 558 page treatise published in 1950. He quietly worked on it making sure that the other two were far removed from his ideas and works.

Revelation came on 23rd January, 1948. He did not sleep that night and paced up and down the hall. By early hours of morning, he finally settled down at the kitchen table. While toying with a slice of bread, he suddenly thought of a sandwich. A three layered sandwich. The outermost layers would be semiconductors with too many electrons, while the layer in the middle would have too few electrons. The middle layer would work like a gate. As the voltage on the gate was adjusted up and

down, it could change the current in the outer layers of the sandwich at will. Thus the first junction transistor was born. Shockley obtained a patent for this invention on 25th September, 1951. This is the most common form of transistor used now.

In 1951, he was elected a member of the National Academy of Sciences (NAS) at the young age of forty-one years. He received the prestigious Comstock Prize for Physics by the NAS in 1953, followed by many more. He left Bell Labs in 1953 and returned to Caltech (California Institute of Technology) as a visiting professor. Beckman Instruments founded Shockley Semiconductor Laboratory in Mountain View, California in 1955 and invited him as the Director. In 1958, he became a lecturer at Stanford University, California.

Shockley separated from his wife Jean in 1954 and married Emmy Lanning on 23rd November, 1955. In February 1956, he founded Shockley Semiconductor Laboratory in Palo Alto, California in an area which has now grown as the Silicon Valley. He heralded Silicon Valley. It is said:

"Shockley is the man who brought silicon to Silicon Valley."

In 1963, he received Maurice Liebman Memorial Prize from the Institute of Radio Engineers, Holley Medal of the American Society of Mechanical Engineers and Oliver E. Buckley Solid State Physics Prize of the American Physical Society. University of Pennsylvania and Rutgers University in New Jersey conferred their honorary science doctorates on him.

Here is a selection from over ninety US patents Shockley received - Semiconductor Amplifier, Bistable Circuits, Forming Semi conductive Devices by Ionic Bombardment, Process for Growing Single Crystals, Method of Growing Silicon Carbide Crystals. His last patent was granted in 1968.

Later in his life, Shockley propounded controversial theories on intelligence by race. Interestingly, he even donated his sperm to a sperm bank, the Repository for Germinal Choice in the

hope of spreading humanity's best genes. In 1989, he died of prostate cancer.

Shockley enlivened his classes with his simple examples. Amplification is one of the basic functions of transistor. One day a student asked him to explain amplification in simple language. Shockley told him: "If you take a bale of hay and tie it to the tail of a mule and then strike a match and set the bale of hay on fire, and if you then compare the energy expended shortly thereafter by the mule with the energy expended by yourself in striking of the match, you will understand the concept of amplification."

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WILSON GREATBATCH

(1919 A.D....)

IMPLANTABLE HEART PACEMAKER

One afternoon in the late 1950s, Greatbatch was building an oscillator to record heart sounds. On powering up the circuit, he observed that it was giving a steady electrical pulse. To his dismay, he soon realised that he used a wrong resistor in a certain place. Recalling the incident, Greatbatch said:

"The oscillator required a 10,000 ohm resistor at the transistor base. I reached into my resistor box for one, but I misread the colour coding and got a 1 mega ohm resistor by mistake."

The circuit was delivering a steady pulse of 1.8 millisecond followed by a 1-second interval. He stared at the thing in disbelief. He was about to desolder it. Wait! He thought for a moment. These pulses and the device could regulate the heartbeat. A deeply religious man, he believed that it was no accident. He felt that the Lord was working through him. After two years of refinement and re-refinement, he had the first successful implantable pacemaker ready with him. Until then, these devices were the size of a television and quite complicated. John Hopps from Canada had invented the first cardiac pacemaker which was much bigger in size than the one Greatbatch built.

Wilson Greatbatch was born in Buffalo, New York, on 6th September, 1919. He received his preliminary education at public schools in West Seneca, New York. Electricity and Electronics always fascinated him and he was thoroughly hooked to them. He built his first two-tube short-wave receiver and a radio transmitter in 1936; relayed storm messages from New England and received a citation from the American Red Cross. He became a Third Class Naval Radioman in 1938. While he was on the aircraft carrier USS Monterey in the dive-bombing squadron, his deck officer was the former US President Ford. By the end of World War II, he married Eleanor and returned to Buffalo. He worked for the New York Telephone Company for a year.

Then he joined electrical engineering at Cornell University and got his bachelor's degree in 1950. Speaking of his student days there, he said:

"Cornell was wonderful! The breadth of background Cornell gave me, has enabled me to branch out, and the countless other things I have had to do in the past decades to keep our corporate heads above water."

He received his postgraduate degree from the State University of New York at Buffalo in 1957.

Greatbatch started developing amplifiers to measure the heart rate and blood pressure of animals for the Psychology Department and participated in their experiments. This activity later helped him to construct amplifiers and he built one for the first monkeys sent into space. Those were the days commercial transistors were just getting available, thanks to Bardeen, Brattain and Shockley.

In Buffalo, there was a group of engineers and doctors at the 'Institute of Radio Engineers' and 'Professional Group in Medical Electronics' respectively, where geniuses in both the fields exchanged their ideas and solved mutual problems. Greatbatch met Dr. Chardack there and broached his pacemaker idea to him. Doctor looked at him strangely and said, "If you can do that, you can save ten thousand lives a year."

Soon after that, first implantable model was planted inside a dog within three weeks. No medical equipment manufacturer came forward to support him. He took a calculated risk, quit his job, left some money for the family and started making pacemakers in the barn behind his house and made fifty pacemakers.

He worked in collaboration with Earl Bakken and his Medtronic Company. Their first successful human implantation in 1960 lasted longer than a year. He patented implantable pacemaker in 1962. But original batteries used were mercury type which did not last long, developed gases and hence could not be hermitically sealed. The first lithium battery invented by James Moser solved these problems. The first pacemaker using this battery had a life of more than 22 years. From 1961 until 1970, he had a license agreement with Medtronic and had complete design control.

Greatbatch once recalled:

"For some months every transistor that was used worldwide in Medtronic pacemakers got tapped in my bedroom."

Again when Medtronic went bankrupt, he took over, joined their Board of Directors and brought it to number one position again.

Greatbatch personally owns more than 200 patents. He made important developments in the lithium batteries, increased the power density and life, reduced the size and internal resistance making them indispensable for pacemakers and implantable defibrillators and made them more reliable. He proved that history had repeatedly shown that when a new method or material becomes available, new uses for it arise. Lithium batteries now have a host of uses.

In 1982, he wrote the book '25 Years of Pacing'. He turned his attention to environment and AIDS. He is looking forward to alternative energy sources, solar power and Helium-III fusion energy. He said:

"There is more He-3 energy on the Moon than we have ever had in the form of fossil fuels on Earth. All we have to do is to go there and get it."

He even built a solar-powered canoe.

Houghton College awarded him honorary doctor's degrees in 1970 and State University of New York at Buffalo in 1984. Lemelson-MIT Prize Program chose Wilson Greatbatch for the Lifetime Achievement Award Winner in 1996. His invention was selected as one of the ten greatest engineering contributions in the last 50 years by the National Society of Professional Engineers in 1985.

It is just enough to conclude this article with the concluding words of his new book 'The Making of the Pacemaker':

"Each worthwhile thing that I have ever done took about ten years to do. It involved living the project all my waking hours, often with no pay for what I did. The doing was the reward. Being paid, asking for success, and peer approval were all insignificant..... I think now that it is the right way. The good Lord doesn't really care whether you succeed or fail. My most abject failure may be a part of some grand success in His sight that may never take place until long after I'm gone. Thus, I shouldn't fear failure or crave success. To ask for a successful experiment, for professional stature, for financial reward, or for peer approval is asking to be paid for what should be an act of love. I do believe He wants me to try and to try hard, but the reward is in the doing, not in the results. So, I'll never get a swelled head over success or shoot myself over failure because I really don't care. I'll be happy however things go, just for the opportunity to try."

Greatbatch credits God for all the success:

"I frequently go to the Lord in prayer to ask Him what He wants me to do and I always get the answer."

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WOLFGANG ERNST PAULI
(1900 - 1958 A.D.)

PAULI'S PRINCIPLE

Though this scientist was nominated for Nobel Prize for eight years, it eluded him. Finally Einstein sent a telegram to the Nobel Committee in 1945:

"Pauli's contribution to modern Quantum Theory consisting in the so-called Pauli or Exclusion Principle became fundamental part of modern Quantum Physics. One wonders what to admire most, the psychological understanding for the development of ideas, the sureness of mathematical deduction, the profound physical insight, the capacity for lucid, systematical presentation, the knowledge of the literature, the complete treatment of the subject matter, or the sureness of critical appraisal."

Only then Pauli was awarded the Nobel Prize in 1945 for his work.

Wolfgang Ernst Pauli was one of the most perfectionist physicists of the twentieth century. He earned the title of 'Conscience of Physics'.

Wolfgang Pauli was born on 25th April, 1900 to Wolfgang Joseph and Berta Camilla. Pauli's middle name Ernst was given to him by his father in honour of Ernst Mach, Pauli's godfather.

Pauli felt that his relationship with Mach was the most important event in his intellectual life.

He graduated from the Doblingen Gymnasium in July 1918 with distinction, before joining the Ludwig-Maximilian University at Munich. Pauli was awarded Ph.D in 1921. Sommerfeld asked Pauli to write a review article on relativity for the prestigious German Encyclopeadia of Mathematics. The article, running into 233 pages is still a standard reference. In the words of Einstein:

"Whoever studies this mature, grandly conceived work would not believe that the author is a twenty-one year old man."

Pauli and Heisenberg were friends and life-long professional collaborators. Heisenberg comments:

"Wolfgang was a typical night bird. To Sommerfeld's dismay, he would therefore rarely attend morning lectures and would not turn up until about noon."

In October 1921, he joined the University of Gottingen as Max Born's assistant. Pauli first met Niels Bohr there, in 1922. Recalling his first meeting, Pauli wrote:

"A new phase of my scientific life began when I met Niels Bohr personally for the first time."

After Copenhagen, Pauli went to the University of Hamburg. In 1928, Pauli became Professor of Theoretical Physics at the Federal Institute of Technology at Zurich and nurtured it as a great centre of Theoretical Physics.

Pauli was the first to postulate the existence of neutrino, an uncharged and almost massless particle which carries off energy in radioactive beta decay. On 17th June, 1931, New York Times reported:

"A new habitant of the heart of the atom was introduced to the world of physics today when Dr. W. Pauli of the Institute of Technology in Zurich, Switzerland, postulated the existence of particles which he christened neutron."

However, in 1934, Enrico Fermi called Pauli's particle a 'neutrino', which is Italian for little neutral one. The existence of this particle was experimentally proved in 1956.

Pauli's most noteworthy contribution was his exclusion principle, which states that no two electrons in an atom can exist in exactly same state, with the same quantum numbers. Electric properties of metals and spin and statistics for elementary particles are his other areas of significant contributions.

In 1931, Pauli was awarded the Lorentz Medal in Amsterdam. In 1953, Pauli was elected a Fellow of the Royal Society of London. He was also a Fellow of the Swiss Physical Society, the American Physical Society, and the American Association for the Advancement of Science. In 1958, Pauli was awarded the Planck Medal.

His first marriage with Kathe Margarethe Deppner lasted less than a year. After the divorce, Pauli had a severe breakdown and resorted to drinking. Pauli died on 15th December, 1958 in Zurich.

Physicist Wolfgang Pauli postulated the existence of neutrinos. He felt that these particles could not be shown experimentally. He challenged anybody to experimentally show the existence of neutrinos and promised them with a full case of champagne. C. Cowan and F. Reines proved just that twenty-five years later. Pauli kept his word. He sent the promised case of champagne to their doorstep.

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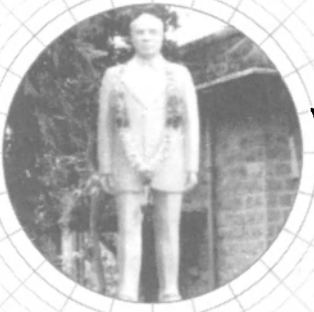

YELLAPRAGADA SUBBA RAO
(1895 - 1948 A.D.)

AUREOMYCIN AND HETRAZAN

It was September 1994. The government hospitals, nursing homes and general clinics started facing shortage of beds and outpatient facilities were getting congested. Scenario was grim as more and more persons were swarming with complaints similar to acute pneumonia in Surat (Gujarat). For some time, the doctors were befuddled with the symptoms but a preliminary diagnosis of pneumonic plague was certain.

Chaos reigned supreme, rumour was the ruler. In one night, 600,000 people fled Surat by every means possible. Even the doctors fled the city. Delhi soon began to feel the tremors and the scare soon reached the southern parts of the country along with the epidemic. Panic struck far and wide and scare was the order of the day. Soon the streets became empty in Bombay (now Mumbai), in Delhi, and Calcutta (now Kolkata). India's tourism industry suffered most and export orders worth 4-billion dollar were cancelled outright from India.

But the panic evaporated almost as fast as it had struck. The killer disease was cleaned out within just three weeks. The deadly disease could take a toll of only 56 persons compared to the past when thousands of people were killed with plague. The real hero was tetracycline and the man who created it. This man, though, no longer alive by then,

paid his debt to his Mother land. India was fortunate to be the birth place of Yellapragada Subba Rao, just hundred years ago. It was fortunate again as the drug discovered five decades ago and thought to be ineffective still worked. In fact, Yersina pestis, the organism that caused the disease had not acquired resistance to tetracycline, so the drug was still as effective. The medicine was in ample supply as half a million capsules were distributed in Surat alone. A major outbreak was thus averted.

Yellapragada Subba Rao was born in Bhimavaram, Andhra Pradesh, India on 12th January, 1895. At thirteen, he ran away from his poverty-stricken home in search of wealth and fame in the holy city of Benares. Brought back, he tried to join the Ramakrishna Mission. His father Jagannadham died in January 1913. His mother had to sell her jewellery to provide for his education, but he could pass through his matriculation only after third attempt. However his vision was clear, as he told his mother:

"I must win a name in the world. Then only would life be worthwhile."

He joined the Madras Medical College, in 1915 with financial help from his friends and his future father-in-law. With an inspiration from Gandhiji's call to boycott British goods, he started wearing surgical gloves made of khadi. With the result, he was awarded the lesser LMS certificate and not the MBBS degree. Subba Rao could not take up the Madras Medical Service and joined the Madras Ayurvedic College with a hope to gain from ancient knowledge. Ayurveda once saved him from the jaws of death while his brothers succumbed to the dreaded disease 'tropical sprue'. But after a chance meeting with an American doctor on a visit, he realised his goal was far away. With support from M S N Charities, Kakinada and financial help from his father-in-law, he landed in Boston on 26th October, 1923.

After a diploma from the Harvard School of Tropical Medicine, he joined Harvard as a junior faculty member. Two chemicals which store energy in our body, Phosphocreatine and Adenosine Triphosphate were discovered by Subba Rao along with Cyrus Fiske. Energy is stored in all living organisms as Phosphocreatine. When the body needs energy, ATP is converted into ADP (adenosine diphosphate) and ATP is replenished by Phosphocreatine while the body rests. He developed 'Rapid Colorimetric Method' to estimate phosphorus in living beings, known as 'Fiske Subba Rao Method'. This is still used by biochemists.

The seniors at the Harvard could not visualise the caliber of Subba Rao. But Lederle Laboratories did that in full measure, as his researches resulted in a new drug each year. Subba Rao and his team isolated folic acid Vitamin B9 from liver and by 1945 he synthesised it. Folic acid is used for the treatment of the dreaded tropical sprue which took him almost into the jaws of death and had also taken away his two brothers. Flour, pasta and other grain products are enriched with folic acid and is now considered as male fertility drug.

He was the father of Methotrexate, the drug originally used in cancer treatment. It is now widely used for rheumatoid arthritis and psoriasis, disabilities of joints and skin and is finding new uses everyday. Hetrazan, the most extensively used drug against Filariasis was a discovery of Subba Rao, which was unveiled on 17th October, 1947. It is now used as prevention and cure by most nations against the endemic of filariasis and consequent elephantiasis disease. Then he was also instrumental in isolating Vitamin B12. American Cynamid named a new fungus, 'Subbaromyces splendens' in his honour.

The next in the list is Aureomycin, the first broad-spectrum antibiotic. It was much more potent than Fleming's penicillin or Waksman's streptomycin. As a matter of fact, Florey and Heatley visited Lederle Laboratories at Pearl River for a sample on

9th September, 1941. Almost every one of us must have used this powerful drug one time or the other in our lives.

While Aureomycin was being presented on 21st July, 1948 to the New York Academy of Sciences by his assistant Benjamin Duggar as the 'discoverer,' Subba Row sat in the back row discussing future plans. He felt:

"The victories of science are rarely won single handed. No one man should get the credit."

Despite his scientific brilliance, he generally gave credit to someone else. His magnanimity, modesty and self-effacement were often dubbed as poor businessman qualities. Interestingly, he did not even get his green card in US.

Goddess Death was jealous of him as there was no end to his miracles. Living Subba Rao was dangerous to the deeds of Death. Just two weeks after that presentation, Subba Rao died in sleep at Pearl River on the night of 8th August, 1948.

The New York Herald Tribune hailed him as one of the most eminent medical minds of the century.

The Jewish Advocate was more succinct in calling him a giant among pygmies. Subba Rao has turned out to be one of the most highly cited scientists in the entire history of science.

Dr. Pushpa Mitra Bhargava, Molecular Biologist, says:

"I do not believe there is any other person in the documented history of Biology and Medicine over the last 5000 years who made such a large number of basic discoveries that are applied so widely. What is Nobel Prize for him and what is Bharat Ratna for such a man of miracles in Medicine."

His last wish was:

If God will spare me another couple of years, may be we can cure another disease.

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A delightful journey into the biographies of some of the pioneering scientists through their trials and tribulations, struggles and challenges, dreams and delusions, endeavours and achievements!

Here we have scientists who missed Nobel Prize and those whom Nobel missed. • A Nobel Prize awarded to Pauling was branded as an insult! But he is the only one to receive two unshared Nobels. • Bardeen returned to Swedish king for another Nobel as if to fulfill earlier promise. • Ironically an Agricultural Scientist received a Nobel Peace Prize. Yes! What is peace without food? • An anguished Barbara Mc Clintock refused to publish her papers, but Nobel committee discovered her.

• Then we have scientists who received awards in prison cells, scientists who made discoveries in the prison cells. • Tesla was thrown out of his labs, cheated by another great man but his alternating current runs our homes now. • Carlson went from pillar to post with his photocopy machine and it is now the Xerox. • Townes had a revelation for LASER on a park bench. • When Maiman made it practical, a Hollywood actress, Bette Davis wondered if it is a death Ray.

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K. Krishna Murty has already fielded two books on Popular Science, this being his third creative venture. A mechanical engineer by profession, he has an ardent passion for science and electronics. He also has numerous published articles to his credit in 'The National Science Magazine, Science Reporter, Indian Express and Telugu magazines apart from a number of enlightening talks broadcast on A.I.R, Vishakhapatnam.

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